ser. 2
v. 24
Nov.
1857

THE

# AMERICAN JOURNAL

OF

# SCIENCE AND ARTS.

CONDUCTED BY

PROFESSORS B. SILLIMAN, B. SILLIMAN, JR.,

AND

JAMES D. DANA,

IN CONNECTION WITH

PROF. ASA GRAY, OF CAMBRIDGE,
PROF. LOUIS AGASSIZ, OF CAMBRIDGE,
DR. WOLCOTT GIBBS, OF NEW YORK.

---

SECOND SERIES.

VOL. XXIV.—NOVEMBER, 1857.

WITH SEVEN PLATES.

NEW HAVEN: EDITORS.

E. HAYES, PRINTER.

MISSOURI BOTANICAL
GARDEN LIBRARY

# CONTENTS OF VOLUME XXIV.

## NUMBER LXX.


Page.

ART. I. On the General Distribution of Terrestrial Magnetism in the United States, from observations made in the U. S. Coast Survey and others; by A. D. BACHE, Superintendent, and J. E. HILGARD, Assistant U. S. Coast Survey. With two maps, 1

II. On the Cyclones or Typhoons of the North Pacific Ocean; with a Chart, showing their Courses of Progression; by W. C. REDFIELD. With a Plate, - - - - - - 21

III. Reply to Dr. F. A. Genth's remarks on the Minerals of the Canton Mine; by CHARLES UPHAM SHEPARD, - - - 38

IV. On a Modified form of Ruhmkorff's Induction Apparatus; by E. S. RITCHIE, - - - - - - - - - 45

V. Caricography; by Prof. C. DEWEY, - - - - - 46

VI. The Self-sustaining power of the Gyroscope analytically examined; by Maj. J. G. BARNARD, A. M., Corps of Engineers, U. S. A., - - - - - - - - - 49

VII. Observations upon the Cretaceous Strata of the United States with reference to the Relative Position of Fossils collected by the Boundary Commission; by JAMES HALL, - 72

VIII. Researches on the Ammonia-cobalt Bases; by WOLCOTT GIBBS and F. A. GENTH.—Part I—(concluded), - - 86

IX. Fourth Supplement to Dana's Mineralogy; by the Author, 107

X. A few remarks in answer to Prof. C. U. Shepard's "Reply;" by F. A. GENTH, - - - - - - - - 133

XI. Notice of a Meteoric Stone which fell at Petersburg, Lincoln county, Tennessee, August 5th, 1855; by CHARLES UPHAM SHEPARD, - - - - - - - - - 134

XII. On the Separation of Magnesia and Lithia; by J. W. MALLET, Ph.D., - - - - - - - - 137


INDIANA

## SCIENTIFIC INTELLIGENCE.

*Chemistry and Physics.*—A new oxyd of Silicon: On the artificial production of Glycerine: Preparation and properties of Manganese, 140.—On crystallized Chromium and its alloys: On some general methods of preparing the elements, 141.—On the amids of the monobasic acids: On a new series of organo-thionic acids, 142.—Note on Ritchie's improved Ruhmkorff's Apparatus, by the author: Silica and alumina in the ashes of Lycopodium, 143.

*Mineralogy and Geology.*—Supplement to the Fifth edition of a Manual of Elementary Geology, by Sir CHARLES LYELL, 143.—Report on the Geological Survey of South Carolina, by OSCAR M. LIEBER, 145.—New Fossil Fishes from the Devonian Rocks of Ohio, by J. S. NEWBERRY, M.D., 147.—Report on the Economical Geology of the route of the Ashtabula and New Lisbon Railroad, by J. S NEWBERRY, M.D.: Descriptions of new Fossil Species of Mollusca, collected by Dr. F. V. Hayden, in Nebraska Territory, by F. B. MEEK and F. V. HAYDEN, 149.—Proportion of Bivalves of different Geological Ages: Slaty Cleavage, 150.—The genus Palæotrochis of Emmons, 151.

*Botany and Zoology.*—Introduction to Cryptogamic Botany, by Rev. J. M. BERKELEY, M.A., F.L.S., 151.—Witterung und Wachsthum, oder Grundzüge der Pflanzenklimatologie, i e. Weather and Growth, or Elements of Climatology as affecting Plants, by H. HOFFMANN, M.D., etc.: Revisio Potentillarum Iconibus Illustrata, auctore C. LEHMANN, 153.—Conspectus Systematicus Hydrillearum, auctore R. CASPARY, 154.—Mémoire sur le Vallisneria spiralis, L., par AD. CHATIN: Freshwater Bivalves: Agassiz, 155.

*Miscellaneous Scientific Intelligence.*—Cold Weather, 155.—Filtration through Sand, 157.—Density of the Earth: Artesian Well of Mondorf: Notice of a brilliant Meteor seen ne ir Lake Winnibigoshish, Minnesota, by Rev. B. F. ODELL: Prof. Bailey: American Association for the Advancement of Science: Key to the Geology of the Globe, by RICHARD OWEN, M.D., 158.—Coast Survey Report for the year 1855: Fossils of South Carolina, by M. TUOMEY and F. S. HOLMES: The U. S. Naval Astronomical Expedition to the Southern Hemisphere, during the years 1849–1 52: Familiar Astronomy, or an Introduction to the Study of the Heavens, by HANNAH M. BOUVIER, 159.—The Testimony of the Rocks, or Geology in its bearings on the Two Geologies, natural and revealed, by HUGH MILLER: A Manual of the Detection of Poisons, by Medico-Chemical analysis, by Dr. F. J. OTTO: Elements of Chemistry, including the Applications of the Science in the Arts, by THOMAS GRAHAM, F.R.S.L., etc.: Chemical Problems and Reactions, by J. P. COOKE, 160.—*Obituary.*—A. Dufrenoy, 160.

## NUMBER LXXI.

Page.

ART. XIII. Biographical Memoir of François André Michaux; by ELIAS DURAND, - - - - - - - - - 161

XIV. Investigations on the Rock Guano from the Islands of the Caribbean Sea; by WM. J. TAYLOR, - - - - - 177

XV. On the Interaction of Natural Forces; by H. HELMHOLTZ, Professor of Physiology in the University of Königsberg, - 189

Page.

XVI. On the Formation of Craters, and the Nature of the Liquidity of Lavas; by G. Poulett Scrope, Esq., M.P., F.R.S., F.G.S.—(Concluded), - - - - - - - - 217

XVII. On the occurrence of Natro-boro-calcite with Glauber-Salt in the Gypsum of Nova Scotia; by Prof. Henry Haw, 230

XVIII. Arctic Explorations, by Dr. Elisha K. Kane, U. S. N., - 235

XIX. A method of measuring the Angles of Crystals by reflection without the use of a Goniometer; by P. Casamajor, - 251

XX. Explanation of the Motion of the Gyroscope; by H. A. Newton, - - - - - - - - - - 253

XXI. Correspondence of Jerome Nicklès—Academy of Sciences; Distribution of Prizes, 255.—Society for the Aid of the Friends of Science: History of Science; Iron bridges, 258.—Astronomical News: Electric Telegraph; Submarine cable across the British Channel, 259.—Scientific Voyages: Chemical Facts; Different states of Sulphur, 260.—Magnesium, Boron, Aluminium: Waters of Artesian Wells: Photography; the regular Universal Exhibition by the French Photographic Society, 261.—Bibliography, 262.

## SCIENTIFIC INTELLIGENCE.

*Chemistry and Physics.*—On a biacid alcohol, 262.—On the action of light upon chlorid of silver: On the use of the prism in qualitative analysis, 263.—On the Disposition of Force in Paramagnetic and Diamagnetic Bodies, by Prof. Tyndall, F R S., 264.—On M. Petitjean's process for Silvering Glass, by Professor Faraday, D.C.L., F R.S., 268.—Some observations on divided gold, by Professor Faraday, D.C.L., F.R.S., 269.

*Mineralogy and Geology.*—On the probable origin of some Magnesian Rocks, by T. Sterry Hunt, 272.—Chlorids: Agalmatolite, by Dr. C. T. Jackson: Corundum: Slate rock of Hungary, 273.—Notes on the Bermuda Islands, by Andrew Scott. 274.—Note on the Cherokine of C. U. Shepard, by T. Sterry Hunt: Notice of the occurrence of Aragonite near the Arkansas River, by W. J. Taylor: Descriptions of new Species of Fossils from the Cretaceous Formations of Nebraska, by James Hall and F. B. Meek, 275.—Descriptions of new species of Fossils from the Carboniferous Limestones of Indiana and Illinois, by James Hall: On the Cretaceous Fossils of Vancouver's Island, Western America, by F. B. Meek: Notes explanatory of a Map and Section illustrating the Geological Structure of the country bordering on the Missouri River, from the mouth of the Platte River to Fort Benton, by Dr. F. V. Hayden, 276.—Descriptions of New Species and Genera of Fossils collected by Dr. F. V. Hayden in Nebraska Territory in 1856: North Carolina Mountains 277.—Himalayas: Notes and Queries on the drying up of the Yellow River, China, by D. J. Macgowan, M.D., 278.—A Sketch of the Geology of Tennessee, by Richard O. Currey: Devonian Trees: Crinoids, 280.

*Botany and Zoology.*—Journal of the Proceedings of the Linnæan Society, 281.—Synopsis Plantarum Phanerogamicarum novarum omnium per annos 1851-1855 descriptarum, auctore Dr. CAROLO MUELLER, or WALPERS, 286.—Bertoloni, Miscellanea Botanica, 287.—Phycologia Australica, or Figures and Descriptions of Australian Seaweeds: Indigofera Caroliniana: The Crustacea and Echinodermata of the Pacific Shores of North America, by WM. STIMPSON, 288.

*Astronomy*—New Planets: Second Comet of 1857: Third Comet of 1857: New Comet: Zodiacal Light, 289.

*Miscellaneous Scientific Intelligence.*—The Schuyler Tornado, Oneida County, New York, 290.—Examination of a Nickel Meteorite, from Oktibbeha County, Mississippi, by WM. J. TAYLOR, 293.—Meteoric Iron of Mexico: Meteoric Stone, 295, 296.—Cabinets of Minerals for sale: Ray Society, (established in 1844) for the publication of works on Natural History, 296.—*Obituary.*—Prof. Elisha Mitchell, 299.—Climatology of the United States, by LORIN BLODGET, 299.—Explorations in the Dacota Country in the year 1855, by G. K. WARREN: Maury's Wind and Current Charts, 300.—Smithsonian Report for 1856: Proceedings of the American Association for the Advancement of Science, 10th Meeting, at Albany: Eleventh Meeting of the American Assocation, 301.

## NUMBER LXXII.

| | Page. |
|---|---|
| ART. XXII. Thoughts on Species; by JAMES D. DANA, - - | 305 |
| XXIII. Preliminary Researches on the alleged Influence of Solar Light on the Process of Combustion; by Prof. JOHN LECONTE, - - - - - - - - - | 317 |
| XXIV. Researches upon the Influence of Sulphur upon Iron and that of Phosphorus in partially neutralizing the action of the Sulphur; by M. JANOYER, - - - - - - | 330 |
| XXV. On a Subsidence of the Land on the Sea-coast of New Jersey and Long Island; by Prof. GEO. H. COOK, - - | 341 |
| XXVI. Biographical Memoir of William C. Redfield; by Prof. DENISON OLMSTED, - - - - - - - | 355 |
| XXVII. Observations on the Zodiacal Light at Quito, Ecuador, with deductions; by Rev. GEORGE JONES, - - - | 374 |
| XXVIII. On a New Source of Electrical Excitation; by Mrs. ELISHA FOOTE, - - - - - - - - | 386 |
| XXIX. On the Quantitative Assay of Chromium by Blowpipe Processes; by EUGENE W. HILGARD, Ph.D. - - - | 387 |
| XXX. Remarks on Fluorine: Action of Acids on Glass; by JEROME NICKLÈS, - - - - - - - - | 395 |
| XXXI. On Fluoriferous Sulphuric Acid and its purification; by JEROME NICKLÈS, - - - - - - - - | 397 |

Page.

XXXII. On Parthenogenesis, - - - - - - 399

XXXIII. Correspondence of M. JEROME NICKLÈS—Obituary, 408.—Statues of Gay Lussac and Etienne Geoffroy St. Hilaire, 409.—History of Science; The Natural Method in Botany and Zoology: Theory of Substitutions, 410.—Electric Illumination; Atmospheric electricity; theory of thunder: New anesthetic agents, 411.—Anesthesis by the Oxyd of Carbon: Anesthesis by carbonic acid: Preparation of Amylene, 412.—Miscellaneous Researches. (1.) Siliciuret of hydrogen; (2.) Formation of Cane Sugar from Glycerine, of Mannite, etc.; (3.) Researches on Tungsten; Bibliography, 413.

Extracts from the Address of the President of the British Association, Rev. HUMPHREY LLOYD, at the Meeting, Aug. 26, 1857, - - - - - - - - - - 415

## SCIENTIFIC INTELLIGENCE.

*Chemistry and Physics.*—On the calculation of the densities of vapors, 422.—On the combinations of the hydracids with hydrocarburets: On inverse substitutions: On Silicium and the metallic siliciurets, 423.—On the oil of the Dutch chemists, 424.—New derivatives of salicyl and new iodids of organic radicals: On the true formula of oxalic acid, 425.—Protosulphid of Carbon: On Glyoxal and Glyoxylic acid, 426.—On the equivalents of Nickel and Cobalt, 427.

*Geology.*—Geological Report of the Midland Counties of North Carolina, by E. EMMONS, 427.—Illustrations of Surface Geology, by EDWARD HITCHCOCK, LL.D., 430.—Outlines of the Continents: Third Annual Report on the Geological Survey of the State of New Jersey for the year 1856, 433.—Microgeology of Ehrenberg: Note on New Fossils in the Potsdam Sandstone at Keeseville, N. Y., by J. D. DANA, 434.

*Botany and Zoology.*—An Elementary Course of Botany; Structural, Physiological, and Systematic; with a brief Outline of the Geographical and Geological Distribution of Plants, by ARTHUR HENFREY, F.R.S., L.S., &c., 434.—Naudin's Researches into the Specific Characters and the Varieties of the Genus Cucurbita, 440.

*Miscellaneous Scientific Intelligence.*—Studies in Organic Morphology, by JOHN WARREN, 443.—Gyroscope: Rapidity of thought or nervous action, by M. ULE: Smithsonian Contributions to Knowledge, 445.—A Monograph of the Tertiary Entomostraca of England and Ireland, by T. RUPERT JONES, F.G.S.: Terrestrial Magnetism at Brussels and Paris: Fishes of China, 446.—United States Japan Expedition, by Commodore PERRY: Fossils of South Carolina, by M. TUOMEY and F. S. HOLMES: Specimen Tables Calculated and Stereomoulded by the Swedish Calculating Machine: On Fichtelite: Astronomical observations, made under the direction of M. F. MAURY, 447.—Annals of the Astronomical Observatory of Harvard College: Patent Office Report: Illustrated Annual Register of Rural Affairs for 1858; Illustrated Scientific and Descriptive Catalogue of Achromatic Microscopes manufactured by J. & W. Grunow & Co., 448.—Annals of the Lyceum of Natural History of New York: Supposed Meteorite, 449.—New Publications, 450.

Index, 451.

## ERRATA.

Page 123, below middle, transpose "mica pseud." and "unalt'd scapolite."
Page 428, 14th line from bottom, for "*Loccopteris*," read "Laccopteris."

THE

# AMERICAN

# JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

---

ART. I.—*On the General Distribution of Terrestrial Magnetism in the United States, from observations made in the U. S. Coast Survey and others;* by A. D. BACHE, Superintendent, and J. E. HILGARD, Assistant U. S. Coast Survey. With two maps.

DURING the progress of the Coast Survey within the last twelve years, observations of the magnetic elements have been made, under special instructions from the Superintendent, at most of the astronomical stations, and near many capes and harbors where a knowledge of the variation of the compass was requisite for the use of navigation. The number of magnetic stations now amounts to about one hundred and sixty, distributed (irregularly as yet) along the entire seacoast of the United States, on a great portion of which magnetic observations were now made for the first time. The object of this paper is to deduce from the Coast Survey observations, in connection with others of recent date, the general distribution of terrestrial magnetism in the United States, as far as the data available will warrant the conclusions.

These observations have been discussed from time to time under the immediate direction of the Superintendent of the Coast Survey, with the double purpose of determining the distribution of magnetism in different parts of the United States and the local irregularities. Observations have also been repeated at many places where the discrepancies indicated the necessity for such a course, and generally resulted in throwing the discrepancy upon the existence of local attraction.

The area under discussion is so large, and the observations comparatively so sparse, that nothing more than the *general* distribution can at present be attempted. Local deviations from the general system, of greater or less magnitude and extent, are apparent in the table of residuals given at the close of this paper; which must be ascribed mainly to local attraction, since the errors of observation are far less in amount, and point out localities where additional observations will be most useful.

The results of the Coast Survey observations are given in Table I, which gives the latitude and longitude of the stations, the declination, dip, and horizontal intensity of the earth's magnetic force, the date of the observations, and a reference to the particular locality, its geology, and other circumstances.

The record of these observations and the details of methods and instrumental constants will shortly be published as a part of the Coast Survey records and results, for the publication of which Congress has provided. A brief notice will therefore suffice here.

In observing the *declination*, the magnetic meridian has generally been obtained by means of collimator magnets, using Gauss and Weber's transportable magnetometer; while the astronomical meridian was derived from the triangle sides of the Coast Survey, or obtained by direct observations.

The *dip* has been observed with needles of from six to ten inches in length, made by Gambey and by Barrow. Two needles have generally been used; or when one only was employed it has been carefully tested and compared.

The *horizontal intensity* has been determined in absolute measure by vibrations and deflections, according to the methods of Gauss and Lamont. The units of measure are those used in the British surveys.

From the agreement of repeated observations, it is inferred that the uncertainty of the observations at a particular spot does not exceed one or two minutes of arc in the declination and dip, and $\frac{1}{500}$ part of the horizontal force.

The data derived from other sources that are combined with the Coast Survey observations are all of recent date, in order not to introduce much uncertainty into the reduction to a common period. They are:

1. Observations by Lieutenant (now Colonel) Lefroy, of the Royal Artillery, in Canada, along the St. Lawrence, and at Toronto; being part of those published by Colonel Sabine, in the *Philosophical Transactions*, 1846 and 1849.

2. Observations made in connection with the survey of the northeastern boundary; *ibid.*

3. Observations of horizontal intensity in Waterville, Maine, by Professor G. W. Keeley, in 1847; *Phil. Trans.* 1848.

4. Observations by the late Dr. John Locke in various parts of the United States, especially in Ohio and the northwestern

states. (*Am. Phil. Trans.* 1846, and *Smithsonian Contrib.* 1852.) The values of horizontal intensity in this series are originally expressed in terms of the force at Cincinnati, and have been converted into British units through the observations at Toronto, which is one of the stations.

5. Observations in various parts of the middle and western states, by Prof. E. Loomis, *Am. Phil. Trans.*, vols. vii. and viii.

6. Observations made on the Mexican boundary surveys, under the direction of Major W. H. Emory, U. S. A., recently presented by him to the *American Academy of Sciences.*

7. Observations made by Captain Whipple's party in the Pacific railroad explorations, near the 35° parallel of latitude. This series, not heretofore published, was kindly furnished by Captain A. W. Whipple, U. S. Topographical Engineers, and is given in full in Table II. It will be seen that a large number of the stations are at a great elevation above the sea level. The effect of elevation on the action of the earth's magnetism has generally been found insensible, and in the absence of any known correction the observations have necessarily been used without regard to height. The observations have been made with a Fox dip-circle—Cambridge, Massachusetts, being used as a reference station for the intensity. The numbers in the table denoting the total intensity may be considered as referring to the arbitrary scale in which the total force at London is 1·372, with the usual uncertainty on account of secular variation.

For use on the map they have been multiplied by 7·41 to give the total intensity in British units, and by the cosine of the dip for the horizontal force. The factor 7·41 is the ratio of 13·32, the total intensity in British units at Cambridge, Massachusetts, from observations by Professor Bond, and the Coast Survey observations in the vicinity, to 1·798, the reference number in the table.

8. Table III gives some observations of declination not before published, collected from various sources for this discussion.

*Corrections for secular variation.*—The observations in the discussion have been reduced to the common date of January, 1850, by the best values for the annual change that could be arrived at.

The annual change for the declination and dip has been used, as found in the discussions by Mr. C. A Schott, printed in the U. S. Coast Survey report for 1856.

For the northwestern states we deduce from scanty data, and have applied an annual change of from 1′·6 to 2′ decrease of easterly declination.

Determinations of intensity in absolute measure are of so recent a date that but little is known of its secular variation. Observations of the horizontal force at Toronto, Boston, New York, Philadelphia, and Pascagoula, made during the interval between 1843 and 1855, concur in showing an annual decrease of nearly $\frac{1}{1000}$ part of the force. If we suppose the total force to remain

constant, the known increase of the dip would account for a rather larger diminution of the horizontal component; and since it is probable that the total intensity is likewise slightly on the increase, the result obtained from our scanty data may be considered sufficiently well established to be used.

Our knowledge of the secular changes on the Western Coast and in the territories is so deficient that no satisfactory reduction can be applied to the observations. The changes, however, are known to be small, and the observations do not differ greatly in date. Their mean date is about 1852, which may be considered as the period to which the western part of our map corresponds more nearly than to 1850.

*Construction of Maps.*—In the construction of the lines on the maps, both the graphic and analytical methods have been used.

Observations within limited spaces were united into groups, by taking the arithmetical means; a number of such groups were combined by conditional equations of the second degree, amounting to an interpolation by second differences.

The several systems of groups were so arranged as to overlap, and the slight disagreement in the joining was adjusted by an interpolation, partly graphic and partly arithmetical.

When the latitudes and longitudes of stations have appeared unsuitable co-ordinates of position, owing to the stations being distributed in an oblique direction to the meridian, they were carefully projected on a map, and referred by measurement to an assumed axis of co-ordinates in any convenient linear measure; the lines deduced from the conditional equations so formed, being projected according to the same system, the latitudes and longitudes of points in them could be read off and tabulated, the artificial system serving only as a convenient means of interpolation.

On the accompanying maps the lines of equal declination, dip, and horizontal intensity have been drawn only as far as they were warranted by observations. For places within the range of the lines approximate values may readily be obtained by graphical interpolation.

Table IV gives the differences between the observed values at the Coast Survey stations, reduced to 1850, and the corresponding values on the maps. It will be seen that there are a few large residuals, sometimes exceeding 2° in declination, 1° in dip, and $\frac{1}{20}$ of the horizontal force, which belong to isolated stations, (see Mt. Pleasant, No. 5, and Patuccawa, No. 15,) or very limited localities (see stations near Cape Ann, Nos. 20 to 24); in these cases local attraction is too apparent to allow the observations to be used in the construction of the map.

We find, further, that in certain more extended localities the residuals in declination, amounting in the average to about 20′ or 25′, have one sign, indicating a more general deviation from a regular system. Thus, the observed declinations near New

York, eastward to Black Rock, and westward to Princeton, are larger than those deduced, while near Cape May, in the lower part of New Jersey and Delaware, they are less; in the western part of Massachusetts they are greater, in the eastern part they are less. For the want of more ample material, especially of observations in the interior, no attempt has at present been made to represent these irregularities in the system of lines. They are greatest in amount in the eastern and middle states, where the average of the residuals, irrespective of sign, is 16′, excluding the class first noticed. Along the shores of the Gulf of Mexico it is 6′; and on the western coast of the United States it amounts to 10′.

The residuals of the *dip* observations are less than those of the declination, amounting in the average to 9′, and there are a less number of large disturbances. When we consider that the disturbing polarities probably act nearly in the plane of the horizon, we may conclude that the irregularities of the dip should bear a still smaller proportion to those of the declination; and we see that the constant instrumental errors, which are larger for the dip than for the declination, are not without sensible effect on the magnitude of the residuals.

Upon the same consideration it will not be surprising that the residuals of the horizontal force observations are larger in proportion than those of the dip, being, in the mean, about the sixtieth part of the actual values of the horizontal intensities. A variation of 10′ in the dip would correspond to one of the one hundred and twentieth part of the horizontal force.

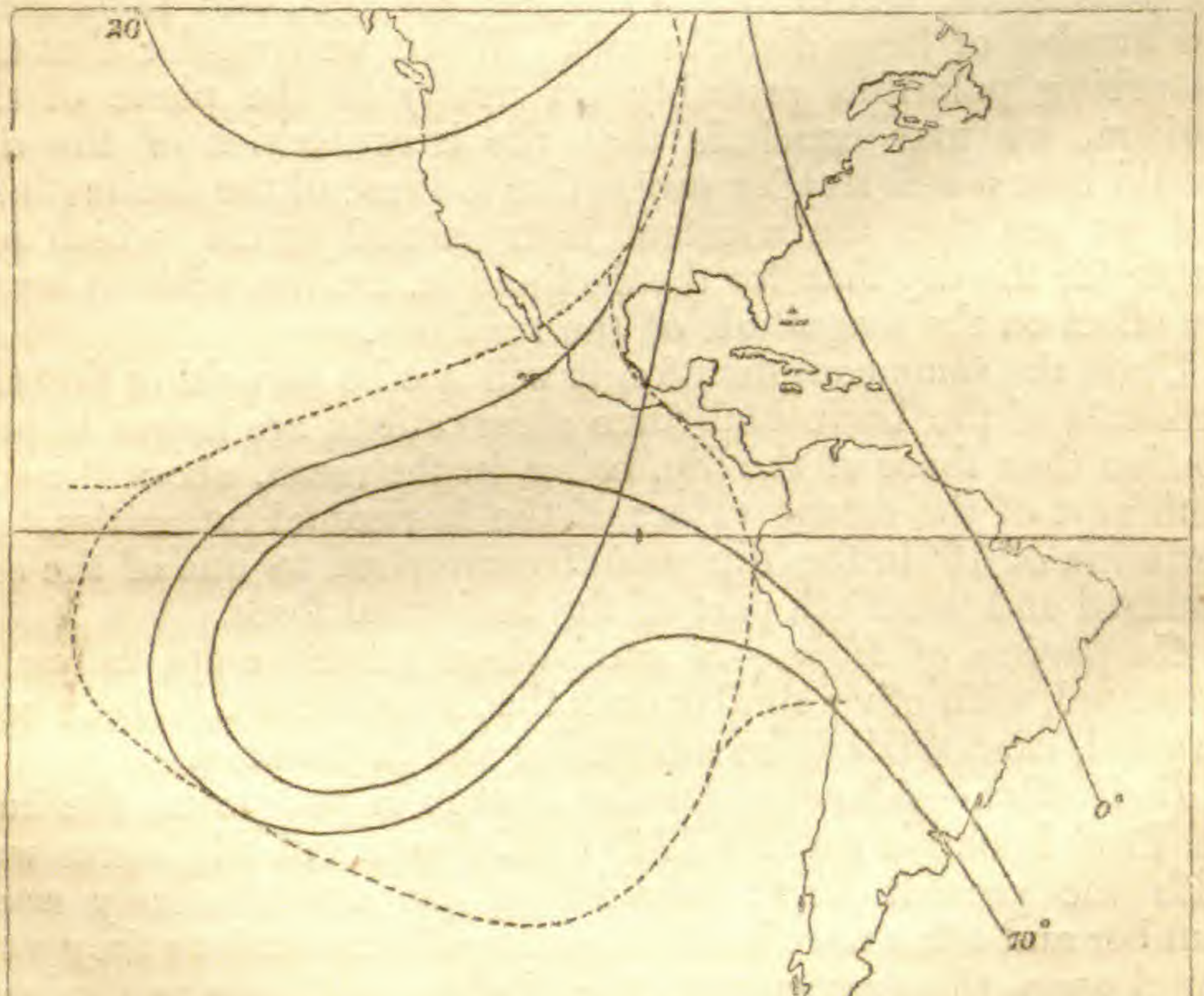
*Comparison of Maps.*—A comparison of the maps herewith presented, with other similar ones that have heretofore been constructed, cannot fail to be interesting and instructive.

*Declination.*—Allowing for the change in ten years, the lines on Prof. Loomis's map for 1840 (*Sill. Journ.* vol. xl), agree well with the present map; considering the comparatively small number and often unreliable character of observations they were based upon, the agreement is remarkable, and leads to the hope that valuable results may be derived from the recent observations made in connection with surveys of public lands in the country west of the Mississippi, in which Burt's solar compass has been used to a great extent.

Colonel Sabine's chart of the declination in the Atlantic ocean (*Phil. Trans.* 1849), covers only the northeastern portion of our map, which in that portion is based in part upon the same observations of 1844 and '45 to 1840, the epoch of the map, the secular change used had not been considerably in error, as already noticed in Mr. Schott's paper on the secular change of the declination (*C. S. Report* for 1855). As it is, the lines agree well in direction, but occupy too nearly the same position for the differences of epoch.

The most important comparison is that with Gauss's maps of the computed values of the declination, dip, and horizontal intensity. They are the only ones in which the three elements have been considered as having a neccessary connection with each other, and while they may be considerably in error as to absolute quantities, the agreement in *form* with the lines on our maps, derived purely from observation, is strong evidence of the general correctness of the assumptions upon which they are based.

The data for the declination were taken by Gauss from Barlow's map in the *Phil. Trans.*, 1833, of which the mean epoch cannot be later than 1830. The system of lines derived by Gauss on theoretical consideration differs in certain localities materially from that of Barlow. The annexed diagram exhibits




the essential difference in form. While Barlow's line of 10° has several branches which diverge tangentially, according to Gauss such a divergence cannot take place; but when there is a space within which the declination is less than outside any portion of its limiting line, that line must form a loop, the two branches intersecting nearly at right angles, as shown in the looped line of 8° 45′. It must be remembered that the region in question is one where very few observations had been made in 1830, and that Barlow's system is probably quite as much as that of Gauss a theoretical interpolation, though graphically performed; and

that hitherto there have been no observed facts, in the region of Texas and New Mexico at least, upon which a decision could be based.

A form of branching similar to that on Barlow's map, and at variance with Gauss' theory, occurs in *Hansteen's Erdmagnetismus*, and has been preserved on a recent map of the declination in his *Magnetiske Inclinations Forandring*, 1855.

It will be seen that if Barlow's system represents the forms correctly, the line of 9° easterly declination along the coast of Texas should turn to the *southeast;* while the line on our map, fixed by numerous observations, decidedly turns to the *southwest*, in conformity with Gauss's system. In going westward along the Mexican boundary, there is not a decrease and subsequent increase, as Barlow's map indicates, but a steady increase, established by the observations along that boundary. The general agreement in form between the lines on our map and the Gauss system is striking. Observations in Central America would at present be of the greatest value in deciding the matter under discussion. The isolated observation at Panama, Table III, has assisted greatly in fixing the direction of the line of 7° east, determining that it still turns to the southeast.

On the Atlantic coast the Gauss lines of declination agree well in position with ours, allowing for the difference of epoch. On the Western Coast, they are farther to the south, which seems contrary to what is supposed to be the secular change.

*Dip.*—With Loomis' map, before quoted, and Sabine's map of the dip in British America (*Phil. Trans.*, 1846), the agreement is excellent. The Gauss lines agree well in form, but differ from 2° to 2½° in the amount of dip. This is due to the errors of Horner's map, from which they are derived, and on which the lines are about 2½° out of position. It must be remembered that they were altogether interpolated, no observations of dip in the United States being known when Horner's map was constructed.

*Horizontal Intensity.*—For a comparison of this element we have only Gauss's chart, on which the lines are affected by the errors of the dip lines, by means of which they have been derived from Sabine's general map of the total intensity for 1836. The values of the Gauss lines being expressed in the arbitrary scale, multiplied by 1,000, we reduce them to absolute measure through the observations at Toronto, where, in 1844, the total intensity in the arbitrary scale was 1·836, the dip 75° 13′·4, and the horizontal force 3·54, in absolute measure in British units, giving a multiplier of 7·56 for the arbitrary scale, or 0·00756 for Gauss values. We find thus 3·78 equivalent to Gauss's line of 500, along which the actual horizontal force is 4·24 to 4·30; in the same place the dip is really 71° 30′, and on Gauss' map, 73° 15′. Corresponding differences exist in other parts of the map.

TABLE I.

| No. | Name of station. | Latitude. | Longitude. | Declinati'n west. | Dip. | Horiz'ntal intensity. | Date. |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 1 | Mount Harris, . . . . . | 44 39.9 | 69 08·5 | 14 34.6 | 76 14·1 | 3·236 | 1855·7 |
| 2 | Ragged Mountain, . . | 44 12.7 | 69 08·7 | 14 16·8 | 75 41·2 | 3·339 | 1854·7 |
| 3 | Camden Village, . . . . | 44 12·0 | 69 05·0 | 13 57·1 | 75 41·5 | 3·340 | 1854·8 |
| 4 | Mount Sebattis, . . . . . | 44 09·1 | 70 04·5 | 12 53·5 | 75 40·6 | 3·411 | 1853·6 |
| 5 | Mount Pleasant, . . . . | 44 01·6 | 70 49·0 | 14 32·1 | 76 01·5 | 3·211 | 1851·7 |
| 6 | Cape Small, . . . . . | 43 46·7 | 69 50·4 | 12 05·5 | 75 01·8 | 3·387 | 1851·8 |
| 7 | Mount Independence, | 43 45·5 | 70 18·9 | 11 46·4 | 75 23·8 | 3·360 | 1849·8 |
| 8 | Burlington, . . . . . | 44 27·5 | 73 10·0 | 9 57·1 | 75 56·8 | 3·425 | 1855·7 |
| 9 | Bowdoin Hill, . . . . . | 43 38·8 | 70 16·2 | 11 41·1 | 75 14·1 | 3·450 | 1851·6 |
| 10 | Richmond Island, . . . | 43 32·6 | 70 14·1 | 12 18·1 | 75 08·0 | 3·463 | 1850·7 |
| 11 | Fletcher's Neck, . . . . | 43 26·8 | 70 20·2 | 11 17·5 | 75 18·3 | 3·440 | 1850·7 |
| 12 | Kennebunk Port, . . . | 43 21·4 | 70 27·8 | 11 23·6 | 75 14·1 | 3·448 | 1851·7 |
| 13 | Mount Agamenticus, . | 43 13·4 | 70 41·2 | 10 09·8 | 74 54·7 | 3·456 | 1847·7 |
| 14 | Cape Neddick, . . . . . | 43 11·6 | 70 36·1 | 11 09·0 | 74 57·9 | 3·516 | 1851·7 |
| 15 | Patuccawa, . . . . . | 43 07·2 | 71 11·5 | 10 42·8 | 76 49·5 | 3·020 | 1849·6 |
| 16 | Kittery Point, . . . . . | 43 04·8 | 70 42·7 | 10 30·2 | 74 57·2 | 3·500 | 1850·7 |
| 17 | Mount Unkonoonuc, . | 42 59·0 | 71 35·0 | 9 04·1 | 75 08·7 | 3·469 | 1848·8 |
| 18 | Isle of Shoals, . . . . . | 42 59·2 | 70 36·5 | 10 03·5 | 74 44·1 | 3·481 | 1847·6 |
| 19 | Plum Island, . . . . . | 42 48·0 | 70 48·5 | 10 05·6 | 74 54·9 | 3·530 | 1850·7 |
| 20 | Annis Squam, . . . . . | 42 39·4 | 70 40·3 | 11 36·7 | . . . . . | . . . . . | 1849·7 |
| 21 | Beacon Hill, . . . . . | 42 36·2 | 70 38·3 | 11 21·1 | 74 26·4 | 3·617 | 1849·7 |
| 22 | Baker's Island Light, | 42 32·2 | 70 46·8 | 12 17·0 | 74 18·6 | 3·674 | 1849·7 |
| 23 | Fort Lee, . . . . . | 42 31·9 | 70 52·1 | 10 14·5 | . . . . . | 3·487 | 1849·6 |
| | " . . . . . | " " | " " | 10 49·7 | 75 36·9 | 3·489 | 1855·7 |
| 24 | Coddon's Hill, . . . . . | 42 30·9 | 70 50·9 | 11 49·8 | . . . . . | . . . . . | 1849·7 |
| 25 | Little Nahant, . . . . . | 42 26·2 | 70 55·5 | 9 40·9 | 74 29·5 | 3·555 | 1849·6 |
| 26 | Dorchester Heights, . | 42 20·0 | 71 02·2 | 9 31·4 | 74 12·7 | 3·587 | 1846·7 |
| | " " | " " | " " | 10 13·7 | 74 29 5 | 3·544 | 1855·7 |
| 27 | Nantasket, . . . . . | 42 18·2 | 70 54·0 | 9 37·4 | 74 15·9 | 3 566 | 1847·7 |
| 28 | Blue Hill, . . . . . | 42 12·7 | 71 06·5 | 9 13·5 | 75 05·6 | 3·519 | 1845·8 |
| 29 | Beacon-pole Hill, . . . | 41 59·7 | 71 26·7 | 9 27·0 | 74 21·9 | . . . . . | 1844·9 |
| 30 | Manomet Hill, . . . . . | 41 55·6 | 70 35·1 | 9 16·9 | 74 30·0 | 3·640 | 1845·7 |
| | " " . . . . . | " " | " " | . . . . . | 74 01·2 | . . . . . | 1846·7 |
| 31 | Copecut Hill, . . . . . | 41 43·3 | 71 03·3 | 9 08·8 | 74 09 5 | . . . . . | 1844·8 |
| 32 | Spencer's Hill, . . . . . | 41 40·7 | 71 29 3 | 9 05·9 | 75 07·1 | . . . . . | 1844·6 |
| 33 | Shootflying Hill, . . . . | 41 41·1 | 70 20·5 | 9 37·4 | 74 23 3 | 3·657 | 1845·6 |
| | " " . . . . | " " | " " | 9 40·3 | 73 56·5 | 3·663 | 1846·7 |
| 34 | Hyannis, . . . . . | 41 37·9 | 70 18·1 | 9 21·6 | 73 49·2 | 3·682 | 1846·6 |
| 35 | Fairhaven, . . . . . | 41 37·4 | 70 53·7 | 8 54·2 | 74 40·0 | 3·592 | 1845·8 |
| 36 | Tarpaulin Cove, . . . . | 41 28·1 | 70 45·1 | 9 12·1 | 73 49·8 | 3·696 | 1846·6 |
| 37 | Indian Hill, . . . . . | 41 25·7 | 70 40·3 | 8 43·9 | 73 41·4 | 3·734 | 1845·6 |
| | " " . . . . . | " " | " " | 8 49·4 | 73 29·1 | 3·728 | 1846·6 |

TABLE I.

*Locality, Geology, and remarks.*

1. Near the geodetic station on the Dixmont hills, Penobscot county, Maine. Talcose slate of a gray color, running E.N.E. and W.S.W., with a dip to the N.N.W. from 80° to 90°.
2. Waldo county, Maine. Gneiss, impregnated with oxyd of iron. Near the geodetic station on the summit.
3. On Penobscot bay, Waldo county, Maine. Gneiss. On ground of Mr. Hugier.
4. At the foot of Mount Sebattis, town of Wales, Maine, in the meadow of Mr. H. Marr. On the top of the hill the declination was found to vary from 9° to 14° in a space of 50 yards. The hill is composed of granite, with quartz veins and detached masses of mica.
5. Town of Denmark, Maine. Granite.
6. Town of Phippsburg, Maine, on the property of M. R. Morrison, fifty yards south of geodetic station.
7. Town of Falmouth, Maine, in a field of Mr. Jos. Hobbes, close to the old road. Drift, clay, and gravel.
8. At the flag-staff on Camp ground, city of Burlington, Vermont. Drift, clay, and sand, 60 or 80 feet deep, overlying limestone and sandstone.
9. In the grounds of J. B. Brown, city of Portland. Drift, sand, and gravel.
10. In a field near the dwelling-house of Dr. Cummings. Talcose and mica slate, intersected by a large trap dyke.
11. Mouth of Saco river, extremity of south point. Metamorphic slates.
12. 150 yards N.N.W. of Kennebunk Port Observatory. Granite.
13. On the summit of Mount Agamenticus, town of York, Maine. Sienite.
14. Town of York, Me., in the field of J. Wyer, on the north side of Cape Neddick river, to the south of and near the road leading to the seashore. Granite underlying the soil.
15. On the summit of the hill, in the town of North Deerfield, N. H. Mica slate.
16. In an enclosure to the east of R. F. Gerrish's cottages. Argillaceous slate.
17. The highest and most easterly summit of that name in Goffstown, 10 miles west of Manchester. Mica slate.
18. On the south side of the harbor of Hog Island, 100 yards from the water. The Isles of Shoals are composed of mica slate and gneiss, with beds of granite ore, and some of them are traversed by dykes of trap.
19. Near Thompson's hotel, on Plum Island, near Newburyport, Massachusetts. Drift covered with sea sand.
20. Sienite. The sienite of the coast of Massachusetts is frequently traversed by dykes of trap, porphyritic trap, &c.
21. On the eastern point of Gloucester, Massachusetts. Sienite.
22. 100 yards from the light, in the direction of Half-way Rock. Sienite.
23. Salem, Massachusetts. Sienite.
" Centre of old fort. Granite, partly covered by clay and sand.
24. Marblehead, Massachusetts. Sienite.
25. On the hill. Sienite.
26. On South Boston Heights, between reservoir and Asylum for the Blind. Drift at least 90 feet deep. Clay and sand, mixed with pebbles.
27. Drift and alluvium, resting on argillaceous slate.
28. Dedham, Massachusetts. Sienite.
29. Near Cumberland Hill village, Rhode Island. Granite. Iron ore occurs near by.
30. Near Plymouth, Massachusetts. Drift.
31. In the town of Fall River, Mass. Granite. Iron ore occurs in the neighborhood.
32. Near East Greenwich, Rhode Island. Metamorphic slate of carboniferous age.
33. Near Barnstable, Massachusetts. Drift.
34. On a hill near Hyannis Point, about 60 feet high. Drift.
35. Opposite New Bedford, Massachusetts, 22 yards east of fort. Gneiss.
36. Nashua, Massachusetts, N.E. of the light, near S. shore of the cove. Drift.
37. Martha's Vineyard. Tertiary strata.

TABLE I—CONTINUED.

| No. | Name of Station. | Latitude. | Longitude. | Declinati'n west. | Dip. | Horiz'ntal intensity. | Date. |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 38 | Sampson's Hill,..... | 41 22·7 | 70 28·7 | 8 48·7 | 73 24·5 | 3·753 | 1846 6 |
| 39 | Nantucket,..... | 41 17·5 | 70 05·7 | 9 14·0 | 73 44·4 | 3·653 | 1846·6 |
| | " ..... | 41 17·5 | 70 05·7 | 9 58·6 | 74 00·6 | 3·626 | 1855·6 |
| 40 | McSparran's Hill,... | 41 29·7 | 71 27·1 | 8 48·5 | 73 47·6 | .... | 1844·6 |
| 41 | Point Judith Light,.. | 41 21·6 | 71 28·6 | 8 59·7 | 73 45·1 | 3·788 | 1847·7 |
| 42 | Providence, R. I..... | 41 50·0 | 71 23·6 | 9 31·5 | 74 15·9 | 3·590 | 1855·6 |
| 43 | Watch Hill,..... | 41 18 8 | 71 50·9 | 7 33·4 | ..... | .... | 1847·7 |
| 44 | Stonington, ..... | 41 20·0 | 71 54·0 | 7 38·1 | 73 25·0 | .... | 1845·6 |
| 45 | Groton Point,..... | 41 18 0 | 72 00·0 | 7 29·5 | ..... | .... | 1845·6 |
| 46 | Saybrook, ..... | 41 16·0 | 72 20·0 | 6 49·9 | 74 33·8 | .... | 1845·6 |
| 47 | Greenport, ..... | 41 06·0 | 72 21·0 | 7 14·4 | 72 57·9 | .... | 1845·6 |
| 48 | Sachem's Head, .... | 41 17·0 | 72 43·0 | 6 15·2 | ..... | .... | 1845·6 |
| 49 | Fort Wooster,..... | 41 16·9 | 72 53·2 | 7 27·2 | 74 16·6 | 3·667 | 1847·7 |
| | " " .. ... | " " | " " | 7 25·5 | 74 12·6 | 3 609 | 1848·7 |
| 50 | Oyster Point,..... | 41 17·0 | 72 55·4 | 6 31·9 | 73 32·9 | 3·761 | 1848·7 |
| | " " ..... | 41 16·9 | 72 55·5 | 7 02·7 | 73 44·5 | 3·690 | 1855·6 |
| 51 | New Haven,..... | 41 18·0 | 72 54·3 | 6 37·9 | 73 31·9 | 3·768 | 1848·6 |
| 52 | Milford, ..... | 41 16·0 | 73 01·0 | 6 38·3 | ..... | ..... | 1845·7 |
| 53 | Bridgeport, ..... | 41 10·0 | 73 11·0 | 6 19·3 | 73 21·3 | ..... | 1845·7 |
| 54 | Black Rock,..... | 41 08·6 | 73 12·6 | 6 53 5 | ..... | ..... | 1845·7 |
| 55 | Norwalk,..... | 41 07·1 | 73 24·2 | 6 49·4 | 73 09·8 | ..... | 1844 7 |
| 56 | Stamford, ..... | 41 03·5 | 73 32·0 | 6 36·0 | 73 02·3 | 3·885 | 1844·7 |
| 57 | Saw-pits, ..... | 41 59·5 | 73 39·4 | 5 58·0 | 72 53·4 | ..... | 1844·7 |
| 58 | Drowned Meadow,.. | 40 56·1 | 73 03·5 | 6 03 6 | ..... | ..... | 1845·7 |
| 59 | Lloyd's Harbor, .... | 40 55·6 | 73 24·8 | 6 11·6 | 72 50·6 | 3·857 | 1844·7 |
| 60 | Oyster Bay,..... | 40 52·3 | 73 31·3 | 6 50·5 | 72 58·8 | 3·894 | 1844·7 |
| 61 | New Rochelle,..... | 40 52·5 | 73 47·0 | 5 29·5 | 72 44·0 | 3·845 | 1844·7 |
| 62 | Sands' Point,..... | 40 52·0 | 73 43·0 | 7 14·6 | ..... | .... | 1845·7 |
| | " " ..... | " " | " " | 6 09·9 | ..... | .... | 1847·8 |
| 63 | Legget, ..... | 40 48·9 | 73 53·0 | 5 41·0 | 72 52·7 | 3·976 | 1847·8 |
| 64 | Greenbush,..... | 42 37·5 | 73 44·0 | 7 54·7 | 75 11·1 | 3·587 | 1855·7 |
| 65 | Cold Spring, ..... | 41 25·0 | 73 57·3 | 5 34·0 | 73 54·8 | 3·790 | 1855·7 |
| 66 | Bloomingd'le Asylum | 40 48·8 | 73 57·4 | 5 09·7 | 72 39·0 | 4·009 | 1846·3 |
| 67 | Columbia College,... | 40 42·7 | 74 00·1 | 6 13·1 | 72 37·8 | .... | 1844·7 |
| | " " .... | " " | " " | 6 25·3 | ..... | .... | 1845·7 |
| 68 | Governor's Island, .. | 40 41·5 | 74 00·8 | 6 39·6 | 72 46·3 | 3·926 | 1855·6 |
| 69 | Bedloe's Island,..... | 40 41·4 | 74 02·3 | 7 02·1 | 72 59·2 | 3·920 | 1855·6 |
| 70 | Receiving Reservoir,. | 40 46·7 | 73 57·8 | 6 28·0 | 72 44·4 | 3·938 | 1855·6 |
| 71 | Newark, ..... | 40 44·8 | 74 07·0 | 5 35·1 | 72 52·2 | 3·964 | 1846·4 |
| 72 | Mount Prospect, .... | 40 40·3 | 73 57·7 | 5 54·7 | 72 27·6 | 4·053 | 1846·3 |
| 73 | Cole, ..... | 40 31·9 | 74 13·8 | 5 37·4 | 72 34·2 | 4·028 | 1846 3 |
| 74 | Sandy Hook, ..... | 40 28·0 | 73 59·8 | 5 51·0 | 72 37·9 | 4·077 | 1844·6 |
| | " " ..... | 40 27·6 | 73 59·9 | 6 11·2 | 72 52·0 | 3·917 | 1855·6 |
| 75 | Mount Rose,..... | 40 22·2 | 74 42·9 | 5 31·8 | 72 42·5 | 4·130 | 1852·6 |
| 76 | White Hill,..... ... | 40 08·3 | 74 43·6 | 4 25·9 | 72 06·2 | 4·147 | 1846·4 |
| 77 | Vanuxem, ..... | 40 06·7 | 74 52·7 | 4 27·8 | 72 22·3 | 4·068 | 1846·5 |

TABLE I.—CONTINUED.

*Locality, Geology, and remarks.*

38. On Chippaquiddick Island, opposite Edgartown, Martha's Vineyard. Drift.
39. On the north beach, near the edge of the town, due N. from Mitchell's Obs'ty. Drift.
" Argillaceous sand, overlying a stratum of clay, resting on gneiss.
40. South Kingston, Rhode Island, in a field near the angle of the roads to Kingston and Wickford.
41. 100 yards towards Beavertail light.
42. In the rear of Brown University, 198 feet from the central building. Quartz and gneiss rocks and mica schist.
43. Half a mile north of Watch Hill lights, near Stonington, Conn. Granitic gneiss.
44. Connecticut. Reddish granitic gneiss.
45. Near New London, Conn. Whitish felspathic gneiss, with mica seams.
46. Connecticut. Granitic gneiss.
47. In Southold, Long Island. Drift.
48. Connecticut. Reddish granitic gneiss.
49. Near New Haven, Connecticut. Trap.

50. Near New Haven, in the meridian of Yale College Observatory. Trap.
" On Howard avenue, 503 feet from high-water mark, on foot of the avenue. Argillaceous soil.
51. Near Pavilion hotel. Sandstone, underlying drift.
52. Greenstone and chloritic slate.
53. Connecticut. Gneiss and mica slate.
54. Connecticut. Gneiss and mica slate.
55. Connecticut. On Judge Isaacs' hill. Granite.
56. Connecticut. In the rear of the Union Hotel. Granite.
57. Steamboat landing at Port Chester, Westchester county, New York. Gneiss.
58. Near Drowned Meadow village, north shore of Long Island. Drift and alluvium.
59. Huntington, Long Island. Drift, with boulders.
60. North shore of Long Island. Drift.
61. About 100 yards south of the Neptune house, in New Rochelle, Westchester county, New York. Gneiss and hornblendic rocks.
62. Forty yards E.N.E. from Sands' Point light. Drift, covered with alluvium.
Near the light-house.
63. In a cove north of Riker's Isl'd., Long Island Sound. Gneiss, covered with alluvium.
64. Opposite Albany, N. Y., near Second street, east of the Hudson River railroad track. Clayey sand and dark blue marl.
65. Near the Hudson river, on a bluff close to the village. Granite.
66. Manhattan Island. Gneiss rock, underlying the soil.
67. City of New York. Gneiss rock, underlying drift, loam and gravel.
City of New York.
68. New York harbor, between Fort Columbus and Castle Williams, in range with Trinity Church steeple and Battery flag-staff. Quartzose sand, overlying mica schist and granite.
69. New York harbor, north side of island, to the northward of the flag-staff. Quartzose sand, overlying metamorphic rock.
70. City of New York, inside the receiving reservoir, near corner of 79th street and 7th avenue. Gneiss.
71. New Jersey. Alluvial soil, sand, and gravel, superimposed on secondary red sandstone in place.
72. Near Brooklyn, L. I. Drift, with small boulders of granite and trap.
73. In Westfield, southwestern part of Staten Island. Drift, with small boulders.
74. 250 yards north of light. Greensand formation; alluvial sand.
" About 250 feet west of the light-house, on the top of a dune. The Hook consists of downs, and the quartz sand was found 25 feet deep.
75. About five miles west of Princeton, N. J., in a field near the house of Mr. Thos. Hunt. Trap rock protruding through secondary red sandstone.
76. Near Bordentown, N. J., on the bank of the Delaware river. Cretaceous marl.
77. At Prof. Vanuxem's, 2 miles above Bristol, on the Delaware river, 100 yards N.W. of the canal. Sand, clay, and gravel, superimposed on metamorphic rock.

TABLE I—CONTINUED.

| No. | Name of station. | Latitude. | Longitude. | Declinat'n west. | Dip. | Horiz'ntal intensity. | Date. |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 78 | Girard College, ..... | 39 58·4 | 75 09·9 | 3 51·1 | 72 01·0 | 4·143 | 1846·4 |
| | " " ..... | " " | 75 09·8 | 4 31·7 | 72 17·7 | 4·226 | 1855·7 |
| 79 | Yard, ..... | 39 58·3 | 75 22·9 | 6 42·3 | 73 01·4 | 3·876 | 1854·8 |
| 80 | Chew, ..... | 39 48·2 | 75 09·7 | 3 45·2 | 72 14·4 | 4·105 | 1846·5 |
| 81 | Tucker's Island, ..... | 39 30·8 | 74 16·9 | 4 27·8 | ..... | .... | 1846·9 |
| 82 | Tuckerton, ..... .... | 39 36·1 | 74 19·5 | ..... | 72 12·3 | 4·063 | 1846·9 |
| 83 | Wilmington, ..... | 39 44·9 | 75 33·6 | 2 30·7 | 71 25·4 | 4·236 | 1846·4 |
| 84 | Sawyer, ..... | 39 42·6 | 75 33·8 | 2 48·3 | 71 57·5 | 4·175 | 1846·4 |
| 85 | Church landing, ..... | 39 40·6 | 75 30·4 | 5 49·1 | 71 22·0 | 4·311 | 1846·4 |
| 86 | Fort Delaware, ..... | 39 35·3 | 75 33·8 | 3 16·8 | 71 34·9 | 4·226 | 1846·5 |
| 87 | Hawkins, ..... | 39 25·6 | 75 17·0 | 2 58·8 | 71 42·6 | 4·224 | 1846·5 |
| 88 | Pine Mount, ..... | 39 25·0 | 75 19·9 | 3 14·2 | 71 41·4 | 4·237 | 1846·5 |
| 89 | Bombay Hook Light, | 39 21·8 | 75 30·3 | 3 18·5 | 71 39·5 | 4·201 | 1846·5 |
| 90 | Port Norris, ..... | 39 14·6 | 75 01·0 | 3 04·4 | 71 39·6 | 4·211 | 1846·5 |
| 91 | Egg Island Light, ... | 39 10·5 | 75 08·0 | 3 03·0 | 71 45·1 | 4·206 | 1846·5 |
| 92 | Town Bank, ..... | 38 58·6 | 74 57·4 | 2 59·0 | 71 23·6 | 4·269 | 1846·5 |
| 93 | Cape May Light, (old), | 38 55·8 | 74 57·6 | 3 05·1 | 71 25·8 | 4·255 | 1846·5 |
| | do. do. (new), | 38 55 8 | 74 57·4 | 3 45·4 | 71 34·4 | 4·182 | 1855 6 |
| 94 | Lewes' Landing, ..... | 38 48·8 | 75 11·5 | 2 45·0 | ..... | .... | 1846·5 |
| 95 | Pilot Town, ..... | 38 47·1 | 75 09·2 | 2 42·7 | 71 18·5 | 4·290 | 1846·5 |
| 96 | Osborne's Ruin, .. .. | 39 27·9 | 76 16·6 | 2 32·4 | 71 47·6 | 4·143 | 1845·5 |
| 97 | Susquehanna Light,.. | 39 32·4 | 76 04·8 | 2 13·7 | 71 52·1 | 4·086 | 1847·5 |
| 98 | Finlay, ..... | 39 24·4 | 76 31·2 | 2 14·6 | 71 52·9 | 4·059 | 1845·5 |
| | " ..... | " " | " " | 2 18·5 | 71 45·2 | 4·170 | 1846·3 |
| 99 | Pool's Island, ..... | 39 17·1 | 76 15·5 | 2 29·3 | 71 52·1 | 4·117 | 1847·5 |
| 100 | Rosanne, ..... | 39 17·5 | 76 42·8 | 2 10·9 | 72 06·6 | 4·053 | 1845·4 |
| 101 | Fort McHenry, ..... | 39 15·7 | 76 34·5 | 2 18·6 | ..... | .... | 1847·3 |
| 102 | North Point, ..... | 39 11·7 | 76 26·3 | 1 36·7 | 71 29·5 | 4·183 | 1846·5 |
| " | " " ..... | " " | " " | 1 39·6 | ..... | .... | 1847·3 |
| 103 | Bodkin Light, ..... | 39 08·0 | 76 25·2 | 2 01·9 | 71 43·1 | 4·189 | 1847·3 |
| 104 | Kent Island (1), ..... | 39 01·8 | 76 18·8 | 2 30·2 | 71 16·6 | 4·208 | 1849·5 |
| 105 | South Base, Kent Isd., | 38 53·8 | 76 21·7 | 2 24·3 | 71 37·0 | 4·206 | 1845·4 |
| 106 | Taylor, ..... | 38 59·8 | 76 27·6 | 2 14·4 | 71 40·2 | 4·231 | 1845·4 |
| " | " ..... | " " | " " | 2 18·0 | 71 19·3 | 4·221 | 1847·4 |
| 107 | Marriott, ..... | 38 52·4 | 76 36·2 | 2 09·4 | 71 10·9 | 4·260 | 1846·4 |
| " | " ..... | " " | " " | 2 05·0 | 71 13·0 | 4·228 | 1849·5 |
| 108 | Webb's Hill, ..... | 39 05·3 | 76 40·2 | 2 07·9 | 71 24·0 | 4·279 | 1850·9 |
| 109 | Soper's Hill, ..... | 39 05·1 | 76 56·7 | 2 07·1 | 71 56·5 | 4·142 | 1850·6 |
| 110 | Hill's Hill, ..... | 38 53·9 | 76 52·5 | 2 18·6 | 71 12·2 | 4·316 | 1850·7 |
| 111 | Causten's Hill, ..... | 38 55·5 | 77 04·1 | 1 11·3 | 71 18·9 | 4·229 | 1851·5 |
| " | " " ..... | 38 55·5 | 77 04·1 | 1 06·2 | 71 30·2 | 4·250 | 1855·7 |
| " | " " ..... | 38 55·5 | 77 04·1 | 1 06·0 | ..... | .... | 1855·8 |

TABLE I—CONTINUED.

*Locality, Geology, and remarks.*

78. In the yard of the magnetic observatory, at Girard College, Philadelphia.
" To the northward and eastward of the college, within the enclosure, and in the road in the rear of the smaller building next to the college. Metamorphic rock, below gravel, etc.
79. About 10 miles west of Philad., and 250 yards E.S.E. of the trigonometrical station.
80. Near Woodbury, N. J. Marl and greensand of the cretaceous formation.
81. Entrance to Little Egg Harbor, N. J., northwestern point of island. Alluvium and white sand.

83. Delaware. A hill 1¼ mile W.N.W. of the town hall. Trap, covered with red clay. Local attraction.
84. Three miles south of Wilmington, Del. At the edge of the tertiary formation, no rocks or boulders apparent.
85. New Jersey, on the Delaware river. Drift. Local attraction ascertained to exist, by partial observations at three localities.
86. Peapatch Island, Delaware river. Alluvial mud at least 70 feet deep.
87. Near Roadstown, N.J. Cretaceous formation. Ferruginous sandstone in vicinity.
88. An isolated hill near Greenwich, N. J. Cretaceous; unmagnetic iron ore.
89. About 60 yards E.S.E. of the light-house. Alluvial clay and sand.
90. New Jersey. Cretaceous marl and sand.
91. Delaware Bay, 60 yards S. by W. of light-house. Cretaceous marl and sand.
92. At Price's, near Cape May. Cretaceous marl and sand.
93. Seventy yards S.E. of light-house. Cretaceous marl and sand.
" About 160 yards west of the light-house, near the sand dunes. Quartz, sand, and broken shells.
94. Near Cape Henlopen.
95. On Cape Henlopen. Clay and sand.
96. Near Abingdon, Maryland. Talcose slate and hornblende.
97. A short distance to N.W. of light-house, at the mouth of the Susquehanna river. Ferruginous clay and sand.
98. On Cub Hill, the property of L. B. Finlay, 9 miles north of Baltimore, on the Harford turnpike. Metamorphic rocks, underlying gravel and sand.
99. Chesapeake Bay, near the dwelling of P. Wethered, on the upper island. Alluvial clay and sand.
100. On Prospect Hill, five miles from Baltimore, north of the old Frederick road. Alluvial clay and sand.
101. Baltimore harbor; between the hospital and western stable. Ferruginous sand and clay.
102. Between the two lights at the mouth of the Patapsco river. Ferruginous sand and clay.
103. Twenty yards S.S.E. from light-house. Ferruginous sand and clay.
104. North end of Kent Island, Chesapeake Bay. Ferruginous sand and clay.
105. On the west shore of Kent Island, opposite Thomas' Point, twenty-one yards north of monument. Ferruginous sand and clay.
106. On the north side of Severn river, opposite Annapolis, Maryland. Ferruginous sand and clay.
107. A prominent hill near West river, Maryland, the property of Bushrod Marriott. Greensand formation, ferruginous clay and marl.
108. Anne Arundel county, Maryland, near the Annapolis railroad, 12 miles from Annapolis. Greensand formation, ferruginous clay and marl.
109. Prince George's county, Md., 14 miles from Washington City, on the old Columbia road; property of J. B. Downs. Talcose slate.
110. Prince George's Co., Md., 6 miles east of Wash'n City. Ferruginous clay and sand.
111. Near Georgetown, D.C., 122 yards west of the geodetic station, in the grounds of J.H. Causten. Mica slate with quartz veins, underlying ferruginous clay and gravel.
" At the geodetic station. 1° 10′·3 in September, and 1° 02′·0 in October, by two different instruments.
" Same station as in June, 1851.

TABLE I—CONCLUDED.

| No. | Name of station. | Latitude. | Longitude. | Declinat'n west. | Dip. | Horiz'ntal intensity. | Date. |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 112 | Washington City,.... | 38 53·2 | 77 01·2 | 5 44·2 | 71 27·0 | 4·337 | 1855·6 |
| 113 | Davis,..... | 38 20·4 | 75 06·0 | 2 33·0 | 70 57·7 | 4·332 | 1853·7 |
| 114 | Roslyn,..... | 37 14·4 | 77 23·6 | 0 26·5 | 69 17·3 | 4·614 | 1852·6 |
| 115 | Stevenson's Point,... | 36 06·3 | 76 10·7 | 1 39·6 | 68 54·5 | 4·660 | 1847·1 |
| 116 | Shellbank,..... | 36 03·3 | 75 43·8 | 1 44·8 | 68 37·8 | 4·714 | 1847·3 |
| 117 | Bodies Island, ..... | 35 47·5 | 75 31·6 | 1 13·4 East. | 68 18·1 | 4 755 | 1846·9 |
| 118 | Raleigh, N. C., ..... | 35 46·8 | 78 37·8 | 0 44·5 | 68 11·6 | 4·943 | 1854·0 |
| 119 | De Rosset, ..... | 34 14·0 | 77 56·5 | 1 13·5 | 66 47·2 | 5·174 | 1854·4 |
| 120 | Columbia, S. C..... | 34 00·0 | 81 02·0 | 3 01·7 | 66 07·7 | 5·274 | 1854·1 |
| 121 | Allston,..... | 33 21·7 | 79 12·3 | 2 06·5 | 65 29·5 | 5·402 | 1853·9 |
| 122 | Macon, Ga..... | 32 50·4 | 83 37·6 | 4 36·5 | 63 51·0 | 5·637 | 1855·0 |
| 123 | Breach Inlet,..... | 32 46·3 | 79 48·7 | 2 16·5 | 64 31·9 | 5·457 | 1849·3 |
| 124 | East Base, Edisto Isd. | 32 33·3 | 80 10·0 | 2 53·6 | 64 04·1 | 5·532 | 1850·3 |
| 125 | Savannah,..... | 32 05·0 | 81 05·2 | 3 40·3 | 63 40·0 | 5·600 | 1852·3 |
| 126 | Tybee Island,..... | 32 01·5 | 80 50·6 | 3 32·1 | 63 38·4 | 5·584 | 1852·3 |
| 127 | Cape Florida,..... | 25 40·4 | 80 09·8 | 4 25·2 | 56 13·0 | 6·615 | 1850·2 |
| 128 | Sand Key,..... | 24 27·2 | 81 52·7 | 5 28·8 | 54 25·8 | 6·758 | 1849·6 |
| 129 | Depot Key,..... | 29 07·5 | 83 02·8 | 5 20·5 | 59 55·3 | 6·140 | 1852·2 |
| 130 | St. Mark's Light, .... | 30 04·5 | 84 12·5 | 5 29·2 | ..... | ..... | 1852·3 |
| 131 | Dog Island,..... | 29 47·1 | 84 36·0 | 5 51·2 | ..... | ..... | 1853·3 |
| 132 | St. George's Island, .. | 29 37·4 | 85 01·1 | 6 02·1 | ..... | ..... | 1853·3 |
| 133 | Cape St. Blas,..... | 29 39·6 | 85 23·9 | 6 06·5 | ..... | ..... | 1854·1 |
| 134 | Hurricane Island,.... | 30 04·4 | 85 40·3 | 6 12·2 | ..... | ..... | 1854·1 |
| 135 | Fort Morgan,..... | 30 13·9 | 88 00·3 | 7 04·1 | ..... | 6·218 | 1847·4 |
| 136 | East Pascagoula, .... | 30 20·7 | 88 31·8 | 7 12·6 | 60 27·2 | 6·220 | 1847·5 |
| | " " .... | " " | " " | 7 08·9 | ..... | 6·174 | 1855·1 |
| 137 | Montgomery, Ala. ... | 32 22·0 | 86 18·0 | 5 18·3 | 63 05·4 | 5·850 | 1855·3 |
| 138 | Fort Livingston, .... | 29 16·7 | 89 48·5 | 7 38·4 | ..... | ..... | 1853·0 |
| 139 | Isle Dernière,..... | 29 02·0 | 90 54·3 | 8 19·2 | ..... | ..... | 1853·1 |
| 140 | Dollar Point,..... | 29 26·0 | 94 52·6 | 8 57·4 | 57 53·3 | 6·541 | 1848·3 |
| 141 | East Base, ..... | 29 12·9 | 94 55·4 | 9 05·0 | 57 42·1 | 6·491 | 1853·2 |
| 142 | Jupiter,..... | 28 54·8 | 95 20·1 | 9 08·7 | 57 11·7 | 6·582 | 1853·4 |
| 143 | Rio Grande, ..... | 25 57·4 | 97 07·6 | 9 00·9 | 52 23·6 | ..... | 1853·9 |
| 144 | San Diego, ..... | 32 42·0 | 117 13·3 | 12 28·8 | ..... | ..... | 1851·3 |
| | " " ..... | " " | " " | 12 31·7 | 57 38·6 | 6·271 | 1853·8 |
| 145 | San Pedro,..... | 33 46·0 | 118 16·0 | 13 30·5 | 59 32·6 | 6·144 | 1853·9 |
| 146 | Point Conception,.... | 34 26·9 | 120 25·6 | 13 50·2 | ..... | ..... | 1850·7 |
| 147 | San Louis Obispo, ... | 35 10·6 | 120 43·5 | 14 16·9 | 59 42·2 | 6·002 | 1854·1 |
| 148 | Point Pinos, ..... | 36 38·0 | 121 54·4 | 14 58·3 | ..... | ..... | 1851·1 |
| 149 | San Francisco, ..... | 37 47·6 | 122 26·8 | 15 26·9 | ..... | ..... | 1852·1 |
| 150 | Bucksport,..... | 40 46·6 | 124 10·7 | 17 06·5 | ..... | ..... | 1853·6 |
| 151 | Humboldt, ..... | 40 44·7 | 124 11·0 | 17 04·5 | ..... | ..... | 1854·3 |
| 152 | Ewing Harbor,..... | 42 44·4 | 124 28·8 | 18 29·7 | ..... | ..... | 1851·9 |
| 153 | Cape Disappointment, | 46 16·6 | 124 02·0 | 20 19·1 | ..... | ..... | 1851·5 |
| 154 | " " | " " | " " | 20 45·3 | ..... | ..... | 1851·5 |
| 155 | Scarboro' Harbor, ... | 48 21·8 | 124 37·2 | 21 29·9 | ..... | ..... | 1852·6 |
| 156 | Waddah Isd. Neéah Bay | 48 22·0 | 124 36·6 | 21 46·9 | 71 07·0 | 4·276 | 1855·6 |

TABLE I—CONCLUDED.

*Locality, Geology, and remarks.*

112. In the Smithsonian Grounds. Affected by local attraction, changing within the enclosure as much as 1½°. Declination on Capital Hill, near Gilliss' station, by compass needle, 2° 25′. Ferruginous clay and sand overlying mica schist.
113. West shore of Sinepuxent Bay, east of Berlin, Md. Ferruginous clay and sand.
114. Near Petersburg, Virginia. Drift, ferruginous clay.
115. Western point, mouth of Little river, Albemarle S'd, N.C. Tertiary clay and sand.
116. On Albemarle Sound, east point of entrance into Currituck Sound. Alluvial mud, sand, and shells.
117. N. Carolina, near the beach, about 5 miles N.N.W. of light-house. White sand.
118. 105 ft. E. and 26 ft. N. of centre of Capital dome. Granitic rock beneath the soil.
119. On a lot adjoining Dr. Drane's residence, north side of Market street, Wilmington, N. C. Tertiary clay, gravel, and sand.
120. In the Capital square, near the southwestern corner.
121. Near Georgetown, S. C. Alluvium.
122. 85 yards southwest of Bibb county Male Academy. Clay.
123. On Sullivan's Island, Charleston entrance, S. C. White sand.
124. Edisto Island, S. C. Tertiary formation, alluvial mud, clay, and sand.
125. On Hutchinson's island, in range of Exchange and Presbyterian Church steeples, near the second embankment from the river. Alluvium.
126. Near the mouth of Savannah river, on a sand dune near the boat-house.
127. Inside beach of Key Biscayne, light-house bearing S.W. Black mud, white sand.
128. Near Key West, Florida. A small island on Florida reef, composed of detritus of marine shells and coral.
129. Cedar Keys, Fla., on highest point of island. Drifted white sand on alluvial mud.
130. In the salt marsh, about 400 yards north of the light.
131. Apalachicola entrance, (eastern). White sea sand.
132. Near Cape St. George, west entrance to Apalachicola bay, Fla. White sea-sand.
133. Florida. White sea-sand.
134. St. Andrew's Bay, Florida. White sea-sand.
135. 400 yds. N.E. of N.W. bastion of F't. Morgan, Mobile P't, Ala. Drifted white sand.
136. Mississippi. About a mile east of mouth of Pascagoula river, in the village, near shore. Tertiary formation, ferruginous clay and white sand. Dip observed in 1848.
137. Near northeast corner of Capitol Square. Deep red clay.
138. Barataria Bay, Louisiana. Alluvium, covered with drifted white sand.
139. Caillou Bay, La. Alluvium, covered with drifted white sand.
140. On Galveston Bay, 10 miles northwest of Galveston, Texas. Sandy loam.
141. Galveston Isd., 10 miles S.W. of Galveston, ½ mile from Gulf shore. Sandy loam.
142. Four miles southwest of Quintana, Texas, near the beach. Drifted sand.
143. Near the mouth on the American side. Alluvium.
144. California. At the Plaza near the "quarters." Very coarse sandstone. The high ridge of Point Loma is to the west.
" At the Plaza, near the custom-house.
145. Open plain, about 3 miles N. of San Pedro. Gravel, on beds of recent fossil shells.
146. Near mouth of valley of El Coxo. Rich soil. Hills show limestone, quartz, &c.
147. The surrounding hills are of soft limestone, resting on coarse red sandstone, bearing enormous fossil remains, probably of tertiary age.
148. Near Monterey, Cal. Rich soil, on sandstone. Beach formed of granite boulders.
149. Near the Presidio. Surrounding hills, limestone.
150. On the beach. Sand and marsh.
151. At the foot of the western part of the bluff, composed of ferruginous clay and sand, resting on gravel, bearing fossil remains of *elephas primigenius.*
152. Near Cape Orford, Oregon. Geology very varied. South of Port Orford, coal and plumbago. North, limestone, filled with fossil shells.
153. On the beach; white sand, mixed with black ferruginous and auriferous sand. Surrounding hills, basalt.
154. On the summit of the Cape. Horizontal columnar basalt.
155. Near Cape Flattery, Washington Territory. Sand. Surrounding hills varied, limestone principally; basalt cropping out at Tatoosh island.
156. On shore, opposite the island, near Cape Flattery, Washington Territory. Sandstone and shales of coal measures.

TABLE II.

*Magnetic observations made on the Pacific Railroad Explorations, near parallel* 35°, *by Lieut. J. C. Ives, under the directions of Capt. A. W. Whipple, U. S. Top. Engineers.*

| No. ref. | Date. | Name of place. | Lat. | Long. | Elevat'n | Magnetic inclination. | Magnetic declination. | Total magnetic inten. |
|---|---|---|---|---|---|---|---|---|
| | | | ° ′ | ° ′ | | ° ′ | ° ′ | |
| 1 | Aug. 9, 1854 | Cambridge Observatory, .. | 42 23 | 71 07 | .... | 74 34 | 9 30 | 1·798 |
| 1 | May 10, 1854 | " " .. | 42 23 | 71 07 | .... | 74 33 | 9 46 | 1·798 |
| 2 | Oct. 17, 1853 | Albuquerque, ..... | 35 06 | 106 38 | 5026 | 62 28 | 13 25 | 1·689 |
| 3 | Nov. 9, " | Isleta, ..... | 34 54 | 106 40 | 4910 | 62 24 | 13 13 | 1·686 |
| 4 | 12, " | Rio San José, ..... | 35 01 | 107 14 | 5556 | 63 18 | 13 46 | 1·689 |
| 5 | 14, " | Covéro, ..... | 35 05 | 107 26 | 5880 | 62 26 | 13 49 | 1·689 |
| 6 | 15, " | Hay Camp,* ..... | 35 05 | 107 39 | 6081 | 35 39 | 35 56 | 1·566 |
| 7 | 17, " | Agua Fria, ..... | 35 02 | 107 58 | 7757 | 62 05 | 13 25 | 1·687 |
| 8 | 18, " | Prescription rock,† ..... | 35 03 | 108 14 | 7238 | 62 03 | 12 57 | 1·679 |
| 9 | 22, " | Zuni river, ..... | 35 06 | 108 39 | 6336 | 62 02 | 13 24 | 1·683 |
| 10 | 26, " | Arch spring, ..... | 35 05 | 108 48 | 6350 | 61 55 | ..... | 1·682 |
| 11 | 28, " | Cedar Forest, ..... | 35 01 | 108 55 | 6162 | 61 40 | 13 01 | 1·679 |
| 12 | 29, " | Jacob's well, ..... | 35 04 | 109 14 | 3973 | 61 59 | 13 44 | 1·674 |
| 13 | 30, " | Navajo spring, ..... | 35 06 | 109 20 | 5665 | 61 58 | 13 23 | 1·675 |
| 14 | Dec. 1, " | Carriso creek, ..... | 35 06 | 109 32 | 5550 | 62 05 | 13 54 | 1·673 |
| 15 | 2, " | Near Lithodendron creek, . | 35 02 | 109 41 | 5500 | 61 57 | 13 33 | 1·667 |
| 16 | 3, " | " Rio Puerco of the west, | 34 58 | 109 52 | 5110 | 61 46 | 14 00 | 1·668 |
| 17 | 5, " | Colorado Chiquito, or Flax river, ..... | 34 53 | 110 04 | 5015 | 62 15 | 13 42 | 1·670 |
| 18 | 7, " | On Colorado Chiquito, .... | 35 00 | 110 25 | 4735 | 61 54 | 13 40 | 1·665 |
| 19 | 8, " | " .... | 35 01 | 110 30 | 4760 | 61 41 | 13 21 | 1·663 |
| 20 | 15, " | " .... | 35 05 | 110 33 | 4675 | 61 44 | ..... | 1·662 |
| 21 | 16, " | " .... | 35 12 | 110 37 | 4618 | 61 45 | 13 39 | 1·668 |
| 22 | 17, " | " .... | 35 18 | 110 53 | 4594 | 61 55 | 13 42 | 1·667 |
| 23 | 18, " | " .... | 35 21 | 110 56 | 4570 | 62 03 | ..... | 1·678 |
| 24 | 29, " | Saroux spring, ..... | 35 17 | 111 39 | 7378 | 61 33 | 13 52 | 1·659 |
| 25 | Jan. 9, 1854 | Cedar creek, ..... | 35 21 | 112 20 | 5672 | 62 06 | 13 49 | 1·674 |
| 26 | 21, " | Pueblo creek, ..... | 34 56 | 112 46 | 5203 | 61 13 | 13 59 | 1·652 |
| 27 | 23, " | Williams' river,‡ ..... | 34 59 | 112 57 | 5752 | 61 06 | 14 48 | 1·648 |
| 28 | 28, " | " ..... | 35 07 | 113 13 | 4680 | 61 17 | 13 40 | 1·618 |
| 29 | 30, " | Head of White Cliff creek, . | 35 12 | 113 21 | 4784 | 61 14 | ..... | 1·659 |
| 30 | Feb. 1, " | White Cliff creek, ..... | 35 08 | 113 31 | 3526 | 60 48 | 14 42 | 1·648 |
| 31 | 4, " | Big Horse spring, ..... | 35 01 | 113 36 | 2784 | 61 02 | 14 18 | 1·631 |
| 32 | 8, " | Williams' river, ..... | 34 36 | 113 28 | 1657 | 60 36 | 14 02 | 1·622 |
| 33 | 9, " | " ..... | 34 32 | 113 28 | 1450 | 60 44 | 13 58 | 1·627 |
| 34 | 13, " | " ..... | 34 17 | 113 26 | 1015 | 60 14 | 13 24 | 1·631 |
| 35 | 15, " | " ..... | 34 13 | 113 33 | 899 | 60 08 | 13 41 | 1·629 |
| 36 | 16, " | Camp 123, ..... | 34 14 | 113 39 | 868 | 60 10 | ..... | 1·624 |
| 37 | 20, " | Camp 126, ..... | 34 17 | 113 56 | 441 | 60 11 | ..... | 1·623 |
| 38 | 21, " | On Colorado river, ..... | 34 23 | 114 06 | 382 | 60 34 | 14 08 | 1·626 |
| 39 | 22, " | Camp 129, ..... | 34 27 | 114 11 | 416 | 60 35 | ..... | 1·628 |
| 40 | 23, " | Camp 130, ..... | 34 36 | 114 16 | 590 | 60 30 | 13 51 | 1·627 |
| 41 | 25, " | Camp 132, ..... | 34 46 | 114 23 | 432 | 60 48 | 13 36 | 1·629 |
| 42 | Mar. 1, " | Camp 135, ..... | 34 52 | 114 32 | 430 | 60 57 | 13 56 | 1·635 |
| 43 | 3, " | Pai-ute creek, ..... | 35 06 | 114 54 | 2790 | 61 10 | 14 17 | 1·635 |
| 44 | 6, " | Near Marl springs, ..... | 35 11 | 115 33 | 3793 | 60 56 | 13 59 | 1·627 |
| 45 | 7, " | Sand camp, .... ..... | 35 06 | 115 46 | 2038 | 60 49 | ..... | 1·632 |
| 46 | 8, " | Soda lake, ..... | 35 03 | 115 59 | 1002 | 61 07 | 13 51 | 1·633 |

* This camp was upon the south side of the stream of lava which threads the valley of the Rio San José.

† This station was under the northern bluff of El Moro.

‡ Much lava in the vicinity of this station.

TABLE III.

*Magnetic observations from various sources, not heretofore published, and collected for this discussion.*

| Name of place. | Lat. | Long. | Declinat'n. | Date | Authority. |
|---|---|---|---|---|---|
| | ° ′ | ° ′ | ° ′ | | |
| Heiner's Run, N. Branch, Susquehanna, Pa. | 41 21 | 77 48 | + 3 19 w. | 1856 | S. Tyndale. |
| Kelly's Island, west end Lake Erie, | 41 36 | 82 43 | − 2 13 E. | 1846 | U.S. Top. Engin'rs. |
| East Sister Isle, west end Lake Erie, | 41 49 | 82 51 | − 2 18 | 1847 | do. |
| West Sister Isle, west end Lake Erie, | 41 44 | 83 06 | − 2 20 | - - - - | do. |
| Stoney Point, | 41 56 | 83 15 8 | − 2 07 | 1848 | do. |
| Waugoshane Point, Mackinac Straits, | 45 45·4 | 84 55·2 | − 2 13 | 1853 | do. |
| East of Duncan city, " " | 45 36·1 | 84 07. | − 1 53 | 1851 | do. |
| Near Newport, Franklin county, Mo. | 38 34 | 91 06 | − 9 21 | 1839 | Dr. Goebel. |
| do. do. | " | " | − 9 05 | 1849 | do. |
| Fort Union, | 48 00 | 103 59 | −16 48 | 1853 | G'v. I. I. Stevens, N. Pacific Railroad Explorations. |
| Fort Benton, | 47 52 | 110 36 | −19 00 | " | |
| Fort Owen, | 46 31 | 113 58 | −19 25 | " | |
| Fort Walla-Walla, | 46 04 | 118 48 | −19 40 | " | |
| Panama, New Granada, | 8 57·2 | 79 29·4 | − 6 54·6 | 1849 | Mexican Bdry. Sur. |

TABLE IV.

*Residual differences between the Coast Survey observations reduced to* 1850, *and the values obtained from the accompanying maps.*

| No. | Station. | Declination. | | Dip. | | Hor. Intensity. | |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 1 | Mount Harris, | + 14 06 | − 0 6 | 76 02 | + 0 4 | 3·28 | − 0·04 |
| 2 | Ragged Mountain, | 13 54 | − 27 | 75 32 | + 13 | 3·37 | − ·06 |
| 3 | Camden Village, | 13 36 | − 8 | 75 32 | + 12 | 3·37 | − ·05 |
| 4 | Mount Sebattis, | 12 35 | − 6 | 75 35 | + 8 | 3·43 | − ·09 |
| 5 | Mount Pleasant, | 14 24 | − 2 48 | 75 59 | − 20 | 3·22 | + ·15 |
| 6 | Cape Small, | 11 57 | + 19 | 74 58 | + 32 | 3·40 | − ·01 |
| 7 | Mount Independence, | 11 45 | − 3 | 75 24 | + 3 | 3·36 | + ·05 |
| 8 | Burlington, | 9 29 | + 1 | 75 44 | + 10 | 3·46 | − ·11 |
| 9 | Bowdoin Hill, | 11 32 | + 9 | 75 11 | + 10 | 3·46 | − ·03 |
| 10 | Richmond Island, | 12 15 | − 40 | 75 07 | + 8 | 3·46 | − ·01 |
| 11 | Fletcher's Neck, | 11 14 | + 10 | 75 17 | + 1 | 3·44 | + ·02 |
| 12 | Kennebunk Port, | 11 15 | − 6 | 75 11 | − 2 | 3·46 | + ·02 |
| 13 | Mount Agamenticus, | 10 21 | + 30 | 74 57 | + 6 | 3·45 | + ·05 |
| 14 | Cape Neddick, | 11 00 | − 1 | 74 55 | + 8 | 3·53 | − ·03 |
| 15 | Pattucawa, | 10 45 | − 27 | 76 50 | − 1 50 | 3·02 | + ·51 |
| 16 | Kittery Point, | 10 27 | + 15 | 74 56 | + 4 | 3·50 | + ·02 |
| 17 | Mount Unkonoonuc, | 9 10 | + 37 | 75 10 | − 19 | 3·47 | + ·09 |
| 18 | Isle of Shoals, | 10 15 | + 26 | 74 46 | + 8 | 3·47 | + ·07 |
| 19 | Plum Island, | 10 02 | + 19 | 74 53 | − 8 | 3·53 | + ·04 |
| 20 | Annis Squam, | 11 39 | − 1 21 | ----- | ------ | ---- | ----- |
| 21 | Beacon Hill, | 11 23 | − 1 5 | 74 27 | + 9 | 3·62 | − ·02 |
| 22 | Baker's Island Light, | 12 18 | − 2 18 | 74 19 | + 14 | 3·69 | − ·08 |
| 23 | Fort Lee, | 10 16 | − 16 | ----- | ------ | ---- | ----- |
| | " | 10 21 | − 21 | 75 26 | − 53 | 3·53 | + ·08 |
| 24 | Coddon's Hill, | 11 51 | − 1 48 | ----- | ------ | ---- | ----- |
| 25 | Little Nahant, | 9 43 | + 8 | 74 30 | − 3 | 3·55 | + ·09 |
| 26 | Dorchester Heights, | 9 48 | − 9 | 74 16 | + 5 | 3·58 | + ·07 |
| | " " | 9 45 | − 6 | 74 18 | + 3 | 3·57 | + ·08 |
| 27 | Nantasket, | 9 49 | − 4 | 74 18 | + 2 | 3·56 | + ·09 |
| 28 | Blue Hill, | 9 35 | − 5 | 75 10 | − 52 | 3·50 | + ·17 |
| 29 | Beacon Pole Hill, | 9 53 | − 50 | 74 27 | − 18 | ---- | ----- |
| 30 | Manomet Hill, | 9 38 | + 10 | 74 34 | − 27 | 3·62 | + ·09 |
| | " | " | " | 74 04 | + 3 | ---- | ----- |
| 31 | Copecut Hill, | 9 35 | − 29 | 74 14 | − 20 | ---- | ----- |
| 32 | Spencer's Hill, | + 9 32 | − 41 | 75 13 | − 1 20 | ---- | ----- |

The sign + or − shows how the residual is to be applied to the observed value to give that on the map.

TABLE IV—CONTINUED.

| No. | Station. | Declination. | Dip. | Hor. Intensity. |
|---|---|---|---|---|
| | | ° ′ ° ′ | ° ′ ° ′ | |
| 33 | Shootflying Hill, - - - | + 9 58 | − 0 16 | 74 28 | − 0 34 | 3·64 | + 0·10 |
| | " - - - - | 9 57 | − 15 | 74 00 | − 6 | 3·65 | + ·09 |
| 34 | Hyannis, - - - - - | 9 39 | + 4 | 73 51 | 00 | 3·67 | + ·07 |
| 35 | Fairhaven, - - - - - | 9 15 | − 9 | 74 44 | − 55 | 3·57 | + ·19 |
| 36 | Tarpaulin Cove, - - - - | 9 17 | − 17 | 73 53 | − 10 | 3·68 | + ·10 |
| 37 | Indian Hill, - - - - | 9 06 | + 7 | 73 46 | − 5 | 3·71 | + ·08 |
| | " - - - - - | 9 06 | + 7 | 73 32 | + 9 | 3·71 | + ·08 |
| 38 | Sampson's Hill, - - - - | 9 06 | + 15 | 73 28 | + 11 | 3·74 | + ·05 |
| 39 | Nantucket, - - - - - | 9 31 | + 2 | 73 49 | − 12 | 3·64 | + ·14 |
| | " - - - - - | 9 31 | + 2 | 73 49 | − 12 | 3·66 | + ·16 |
| 40 | McSparran's Hill, - - - | 9 16 | − 25 | 73 53 | − 10 | ---- | ----- |
| 41 | Point Judith Light, - - - | 9 11 | − 41 | 73 47 | − 10 | 3·78 | + ·02 |
| 42 | Providence, - - - - | 9 02 | − 5 | 74 05 | − 2 | 3·63 | + ·11 |
| 43 | Watch Hill, - - - - | 7 45 | + 30 | ----- | ------ | ---- | ----- |
| 44 | Stonington, - - - - | 8 00 | + 9 | 73 30 | + 8 | ---- | ----- |
| 45 | Groton Point, - - - - | 7 51 | + 10 | ----- | ------ | ---- | ----- |
| 46 | Saybrook, - - - - - | 7 12 | + 30 | 74 40 | − 1 9 | ---- | ----- |
| 47 | Greenport, - - - - - | 7 37 | − 4 | 73 02 | + 22 | ---- | ----- |
| 48 | Sachem's Head, - - - | 6 37 | + 44 | ----- | ------ | ---- | ----- |
| 49 | Fort Wooster, - - - - | 7 39 | − 30 | 74 19 | − 49 | 3·66 | + ·21 |
| | " - - - - - | 7 32 | − 23 | 74 14 | − 44 | 3·60 | + ·27 |
| 50 | Oyster Point, - - - - | 6 38 | + 28 | 73 34 | − 4 | 3·76 | + ·11 |
| | " - - - - - | 6 35 | + 31 | 73 33 | − 3 | 3·73 | + ·14 |
| 51 | New Haven, - - - - | 6 42 | + 27 | 73 33 | − 2 | 3·78 | + ·08 |
| 52 | Milford, - - - - - | 7 00 | + 3 | ----- | ------ | ---- | ----- |
| 53 | Bridgeport, - - - - - | 6 41 | + 10 | 73 26 | − 2 | ---- | ----- |
| 54 | Black Rock, - - - - | 7 15 | − 33 | ----- | ------ | ---- | ----- |
| 55 | Norwalk, - - - - - | 7 16 | − 43 | 73 15 | + 6 | ---- | ----- |
| 56 | Stamford, - - - - - | 7 02 | − 41 | 73 08 | + 11 | 3·86 | + ·06 |
| 57 | Sawpits, - - - - - | 6 24 | − 12 | 72 59 | + 15 | ---- | ----- |
| 58 | Drowned Meadow, - - - | 6 25 | + 23 | ----- | ------ | ---- | ----- |
| 59 | Lloyd's Harbor, - - - - | 6 38 | − 14 | 72 56 | + 16 | 3·84 | + ·10 |
| 60 | Oyster Bay, - - - - | 7 17 | − 1 2 | 73 04 | + 3 | 3·87 | + ·08 |
| 61 | New Rochelle, - - - - | 5 56 | + 1 | 72 49 | + 18 | 3·82 | + ·14 |
| 62 | Sands' Point, - - - - | 7 36 | − 1 33 | ----- | ------ | ---- | ----- |
| | " - - - - - | 6 21 | − 18 | ----- | ------ | ---- | ----- |
| 63 | Legget, - - - - - | 5 52 | − 7 | 72 55 | + 10 | 3·97 | ·00 |
| 64 | Greenbush, - - - - | 7 26 | − 2 | 74 59 | − 26 | 3·63 | + ·03 |
| 65 | Cold Spring, - - - - | 5 05 | + 1 10 | 73 43 | − 5 | 3·83 | + ·03 |
| 66 | Bloomingdale Asylum, - - | 5 28 | + 20 | 72 43 | + 25 | 4·00 | − ·02 |
| 67 | Columbia College, N. Y. - - | 6 40 | − 1 11 | 72 43 | + 14 | ---- | ----- |
| | " " - - - | 6 47 | − 1 4 | ----- | ------ | ---- | ----- |
| 68 | Governor's Island, - - - | 6 11 | − 38 | 72 35 | + 20 | 3·97 | + ·03 |
| 69 | Bedloe's Island, - - - | 6 34 | − 1 4 | 72 48 | + 6 | 3 96 | + ·05 |
| 70 | Receiving Reservoir, - - - | 6 00 | − 15 | 72 33 | − 31 | 3·98 | − ·04 |
| 71 | Newark, - - - - - | 5 53 | − 20 | 72 56 | − 4 | 3·95 | + ·03 |
| 72 | Mount Prospect, - - - | 6 13 | − 31 | 72 31 | + 29 | 4·04 | − ·06 |
| 73 | Cole, - - - - - - | 5 55 | − 34 | 72 38 | + 9 | 4·02 | + ·01 |
| 74 | Sandy Hook, - - - - | 6 13 | − 43 | 72 43 | + 2 | 4·05 | − ·01 |
| | " " - - - - | 5 43 | + 13 | 72 41 | + 4 | 3·96 | + ·08 |
| 75 | Mount Rose, - - - - | 5 19 | − 31 | 72 37 | 0 | 4·15 | − ·09 |
| 76 | White Hill, - - - - | 4 44 | − 5 | 72 07 | + 17 | 4 14 | − ·04 |
| 77 | Vanuxem, - - - - - | 4 45 | − 15 | 72 26 | + 2 | 4·06 | + ·05 |
| 78 | Girard College, - - - - | 4 09 | 00 | 72 05 | + 11 | 4·13 | + ·01 |
| | " " - - - - | 4 03 | + 6 | 72 06 | + 10 | 4·27 | − ·13 |
| 79 | Yard, - - - - - | 6 18 | − 2 21 | 72 52 | − 36 | 3 91 | + ·23 |
| 80 | Chew, - - - - - | 4 03 | 0 | 72 18 | − 11 | 4·09 | + ·07 |
| 81 | Tucker's Island, - - - | 4 43 | − 4 | ----- | ------ | ---- | ----- |
| 82 | Tuckerton, - - - - | ---- | ------ | 72 26 | − 26 | ---- | ----- |
| 83 | Wilmington, - - - - | 2 49 | + 50 | 71 29 | + 35 | 4 22 | − ·04 |
| 84 | Sawyer, - - - - - | 3 06 | + 33 | 72 01 | − 1 | 4·16 | + ·03 |
| 85 | Church Landing, - - - | 6 07 | − 2 25 | 71 26 | + 31 | 4·30 | − ·10 |
| 86 | Fort Delaware, - - - - | 3 35 | − 2 | 71 38 | + 14 | 4·22 | − 01 |
| 87 | Hawkins, - - - - - | + 3 16 | + 26 | 71 46 | − 1 | 4·21 | + ·02 |

TABLE IV—CONTINUED.

| No. | Station. | Declination. | | Dip. | | Hor. Intensity. | |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 88 | Pine Mount, | +3 32 | +0 7 | 71 45 | − 0 1 | 4·23 | +0·01 |
| 89 | Bombay Hook Light, | 3 36 | − 6 | 71 43 | − 3 | 4·19 | + ·06 |
| 90 | Port Norris, | 3 22 | + 29 | 71 43 | − 6 | 4·20 | + ·05 |
| 91 | Egg Island Light, | 3 20 | + 22 | 71 49 | − 17 | 4·20 | + ·06 |
| 92 | Town Bank | 3 16 | + 29 | 71 27 | − 8 | 4·26 | + ·03 |
| 93 | Cape May Light, (old), | 3 23 | + 19 | 71 29 | − 7 | 4·24 | + ·06 |
| | " " (new), | 3 17 | + 25 | 71 23 | − 1 | 4·22 | + ·08 |
| 94 | Lewes' Landing, | 3 01 | + 23 | ----- | ------ | ---- | ----- |
| 95 | Pilot Town, | 3 00 | + 27 | 71 22 | − 11 | 4·28 | + ·06 |
| 96 | Osborne's Ruin, | 2 55 | − 4 | 71 52 | − 10 | 4·12 | + ·13 |
| 97 | Susquehanna Light, | 2 26 | + 37 | 71 55 | − 7 | 4·08 | + ·16 |
| 98 | Finlay, | 2 37 | − 4 | 71 57 | − 19 | 4·04 | + ·22 |
| | " | 2 37 | − 4 | 71 49 | − 1 | 4·16 | + ·10 |
| 99 | Pool's Island, | 2 42 | + 3 | 71 55 | − 18 | 4·11 | + ·17 |
| 100 | Rosanne, | 2 34 | − 13 | 72 11 | − 37 | 4·03 | + ·26 |
| 101 | Fort McHenry, | 2 32 | − 2 | ----- | ------ | ---- | ----- |
| 102 | North Point, | 1 57 | + 43 | 71 33 | − 4 | 4·17 | + ·13 |
| | " | 1 53 | + 40 | ----- | ------ | ---- | ----- |
| 103 | Bodkin Light, | 2 19 | + 14 | 71 46 | − 17 | 4·18 | + ·12 |
| 104 | Kent Island, (1), | 2 33 | + 6 | 71 17 | + 5 | 4·21 | + ·11 |
| 105 | South Base, Kent Island, | 2 47 | − 20 | 71 41 | − 29 | 4·19 | + ·16 |
| 106 | Taylor, | 2 37 | − 13 | 71 45 | − 26 | 4·21 | + ·12 |
| | " | 2 31 | − 07 | 71 22 | − 3 | 4·21 | + ·12 |
| 107 | Marriott, | 2 27 | − 15 | 71 14 | − 5 | 4·25 | + ·11 |
| | " | 2 07 | + 5 | 71 13 | − 4 | 4·23 | + ·13 |
| 108 | Webb's Hill, | 2 03 | + 15 | 71 22 | + 2 | 4·29 | + ·03 |
| 109 | Soper's Hill, | 2 04 | − 1 | 71 55 | − 31 | 4·14 | + ·19 |
| 110 | Hill's Hill, | 2 15 | − 15 | 71 11 | + 1 | 4·31 | + ·05 |
| 111 | Causten's Hill, | 1 04 | + 44 | 71 16 | − 4 | 4·23 | + ·13 |
| | " " | 0 38 | +1 10 | 71 19 | − 7 | 4·28 | + ·08 |
| | " " | 0 37 | +1 11 | ----- | ------ | ---- | ----- |
| 112 | Washington City, | 5 38 | −3 47 | 71 16 | − 6 | 4·38 | − ·01 |
| 113 | Davis, | 2 14 | +1 1 | 70 50 | − 2 | 4 35 | + ·06 |
| 114 | Roslyn, | 0 13 | + 32 | 69 12 | + 21 | 4·64 | + ·02 |
| 115 | Stevenson's Point, | 1 53 | − 44 | 68 58 | − 22 | 4·65 | + ·14 |
| 116 | Shellbank, | 1 57 | − 27 | 68 40 | − 4 | 4·70 | + ·09 |
| 117 | Bodies Island, | +1 27 | + 3 | 68 21 | + 3 | 4·74 | + ·08 |
| 118 | Raleigh, N. C., | −1 03 | + 11 | 68 04 | − 7 | 4·97 | − ·03 |
| 119 | De Rosset, | 1 30 | + 27 | 66 38 | − 6 | 5·20 | − ·04 |
| 120 | Columbia, S. C., | 3 18 | + 12 | 66 00 | − 9 | 5·30 | ·00 |
| 121 | Allston, | 2 22 | + 10 | 65 22 | + 7 | 5·43 | − ·08 |
| 122 | Macon, Ga., | 4 30 | + 30 | 63 41 | + 28 | 5·67 | + ·01 |
| 123 | Breach Inlet, | 2 14 | − 34 | 64 32 | + 14 | 5·46 | ·00 |
| 124 | East base, Edisto Island, | 2 54 | − 9 | 64 04 | + 23 | 5·53 | ·00 |
| 125 | Savannah, | 3 49 | + 10 | 63 35 | + 13 | 5·62 | ·00 |
| 126 | Tybee Island, | 3 41 | + 8 | 63 34 | + 14 | 5·60 | + ·03 |
| 127 | Cape Florida, | 4 25 | − 8 | 56 13 | + 8 | 6·61 | − ·09 |
| 128 | Sand Key, | 5 29 | + 5 | 54 26 | + 1 | 6·76 | + ·07 |
| 129 | Depot Key, | 5 22 | + 12 | 59 55 | + 8 | 6·15 | + ·04 |
| 130 | St. Mark's Light, | 5 31 | + 1 | ----- | ------ | ---- | ----- |
| 131 | Dog Island, | 5 53 | + 10 | ----- | ------ | ---- | ----- |
| 132 | St. George's Island, | 6 04 | + 10 | ----- | ------ | ---- | ----- |
| 133 | Cape St. Blas, | 6 08 | + 4 | ----- | ------ | - -- | ----- |
| 134 | Hurricane Island, | 6 14 | + 6 | ----- | ------ | ---- | ----- |
| 135 | Fort Morgan, | 7 03 | − 1 | ----- | ------ | 6·21 | ·00 |
| 136 | East Pascagoula, | 7 12 | 0 | 60 30 | − 3 | 6·20 | ·00 |
| | " " | 7 12 | 0 | ----- | ------ | 6·20 | ·00 |
| 137 | Montgomery, | 5 06 | −1 4 | 62 52 | + 20 | 5·89 | − ·10 |
| 138 | Fort Livingston, | 7 40 | − 4 | ----- | ------ | ---- | ----- |
| 139 | Isle Dernière, | 8 20 | + 17 | ----- | ------ | ---- | ----- |
| 140 | Dollar Point, | 8 57 | − 7 | 57 53 | + 7 | 6·53 | − ·04 |
| 141 | East base, | 9 07 | − 4 | 57 42 | − 3 | 6·52 | + ·02 |
| 142 | Jupiter, | 9 10 | − 5 | 57 12 | − 6 | 6·59 | ·00 |
| 143 | Rio Grande, | −9 02 | − 3 | 52 23 | − 7 | ---- | ----- |

TABLE IV—CONCLUDED.

| No. | Station. | Declination. | | Dip. | | Hor. Intensity. | |
|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | |
| 144 | San Diego, - - - - | −12 28 | − 0 21 | ----- | ------ | ---- | ------ |
| | " " - - - - - | 12 32 | − 25 | 57 38 | + 0 33 | 6·30 | − 0·04 |
| 145 | San Pedro, - - - - | 13 37 | + 18 | 59 32 | − 17 | 6·17 | − ·01 |
| 146 | Point Conception, - - - | 13 50 | + 5 | ----- | ------ | ---- | ------ |
| 147 | San Luis Obispo, - - - | 14 13 | + 6 | 59 42 | + 45 | 6·03 | − ·03 |
| 148 | Point Pinos, - - - - | 14 57 | 0 | ----- | ------ | ---- | ------ |
| 149 | San Francisco, - - - - | 15 25 | − 10 | ----- | ------ | ---- | ------ |
| 150 | Bucksport, - - - - | 17 03 | − 14 | ----- | ------ | ---- | ------ |
| 151 | Humboldt, - - - - | 17 00 | − 16 | ----- | ------ | ---- | ------ |
| 152 | Ewing Harbor, - - - - | 18 28 | + 6 | ----- | ------ | ---- | ------ |
| 153 | Cape Disappointment, - - | 20 19 | + 22 | ----- | ------ | ---- | ------ |
| 154 | " " - - - | 20 45 | − 4 | ----- | ------ | ---- | ------ |
| 155 | Scarboro' Harbor, - - - | 21 27 | − 7 | ----- | ------ | ---- | ------ |
| 156 | Waddah Island, Neé-ah Bay, - | −21 41 | + 8 | 71 07 | 0 | 4·32 | ·00 |

*Supplementary Note.*—The following results of observations recently made in Mexico for the Smithsonian Institution are added here, with the permission of the Secretary, from his eleventh report to the Regents.

The observations were made under the direction of Baron Mueller, of Marseilles, by Mr. A. Sonntag, with the modern improved instruments.

| No. | Name of station. | Lat. | Long. | Decl. east. | Dip. | Horizontal intensity. | Mag. mom't. | Date 1856. |
|---|---|---|---|---|---|---|---|---|
| | | ° ′ | ° ′ | ° ′ | ° ′ | | | |
| 1 | Vera Cruz, ..... | 19 12 | 96 09 | 8 17 | 43 58 | 7·533 | 0·4951 | August 7–8. |
| 2 | Potrero, ..... | 18 56 | 96 48 | 8 39 | 42 51 | 7·576 | 0·4946 | August 16–17. |
| 3 | Orizaba, ..... | 18 53 | 97 04 | 8 28 | 42 51 | 7·579 | ..... | August 26–27. |
| 4 | St. Andrés Chalc, | 18 59 | 97 14 | 8 13 | 42 38 | 7·594 | ..... | September 17–18. |
| 5 | Mirador, ..... | 19 13 | 96 37 | 8 02 | 43 48 | 7·528 | 0·4916 | October 9–11. |
| 6 | City of Mexico, .. | 19 26 | 96 05 | 8 46 | 41 26 | 7·581 | 0·4896 | December 10–17. |

1. At the villa La Guaca, two hundred yards south of the city.
2. In the State of Vera Cruz.
3. In the State of Vera Cruz.
4. St. Andrés Chalchecomula. State of Puebla.
5. In the State of Vera Cruz.
6. On the arched roof of the church of the convent of St. Augustine, at the same place where Humboldt made his observations.

ART. II.—*On the Cyclones or Typhoons of the North Pacific Ocean; with a Chart, showing their Courses of Progression;* by W. C. REDFIELD.*—With a Plate.

THE late expedition to Japan, under the command of Commodore Mathew C. Perry, has served to increase our knowledge of the Asiatic seas and the islands of the Pacific Ocean. Among other valuable contributions, the meteorological observations, made and obtained by the officers of the squadron, which relate to the tempestuous cyclones of the Western Pacific, have led to the compilation of a memoir on these tempests, which accompanies Commodore Perry's published account of the expedition. The substance of this memoir, in a more condensed form, is here submitted.

*Commodore Perry's Cyclone of July*, 1853.—The steamships Susquehanna and Mississippi under the command of Commodore Perry, left the Bay of Jeddo in Japan on the 17th of July, 1853, and steered a southwesterly course, with the barometer standing at 30 inches, which is much above its usual height in summer in that region. This state of the barometer, as is evident, was caused by the exterior wave of the great cyclone whose center-path the track of the ships was gradually approaching. On the 18th the wind was at E.S.E. and the barometer commenced falling, which was attended on the 19th by a heavy swell from the southeast quarter, in lat. 31° 14′ N., lon. 135° 03′ E.; the path of the cyclone's center being then at the distance of five hundred and fifty miles, as now estimated. On the 20th the cyclonic wind had veered to East, blowing with increased force, and a "very heavy sea." At 6 P.M. the barometer had falled to 29·36; which, as it fell no lower, indicates the nearest proximity of the ships to the center of the storm. After lying twenty-four hours with head to S.E. the Mississippi was placed with her head to the N.E., when the rise of the barometer was very apparent, as appears by the master's report. The barometer of the Susquehanna at 9 A.M. of the 21st still stood at 29·36; but from this time it continued to rise slowly, and the strength of the gale was found to abate. On the 24th the Mississippi was in lat. 26° 25′, lon. 128° 10′ E. (near to Loo Choo), bar. at 29·60, and the wind of the cyclone had veered to E.S.E. On the 24th, at Loo Choo, the wind had veered round to the southward and the barometer rose to 29·74. On the 27th–28th it reached 29·80, the usual height for July in that region.

* This article was prepared for the press shortly before the death of Mr. Redfield, and was found in manuscript among his papers. As the last of a long series in this Journal by one of the most active men of science in the country, it has an interest independent of its special merits.—EDS.

From the known law which governs the action of revolving storms it follows that the observations already stated are sufficient to show that this gale was an actual cyclone, moving westwardly, in the direction which is common in the trade-wind latitudes north of the equator; that it was of great superficial extent, and very slow in its progression, and that the relative position of these two ships in the cyclone was very far to the right of the path pursued by its axis of rotation. All this was shown by the direction, persistence, and gradual veerings of the storm-wind, between East and South, and its characteristic effects on the barometer, as well as by the relations of these phenomena to the courses and the successive geographical positions of the ships.

There have been instances where vessels in like relative positions in a cyclone have run on in the same course with the storm, for several days, without any appreciable change in the direction and force of the wind; and from which the navigator has inferred, erroneously, that such gale could not have been of a rotary character; while the contrary has been clearly shown by the reports from other vessels exposed to the same gales. A better knowledge of the cyclones, will enable the mariner to avoid this error.

We also have further knowledge of the great extent, the slow progression, and the cyclonic character of this storm, founded on observations made in other localities, in adjacent portions of the Pacific Ocean. The U. S. ship Saratoga sailed from Jeddo Bay with the steamships, bound for Shanghai, on a track more westerly than was pursued by Commodore Perry; it encountered the same strong winds and heavy sea, from nearly the same quarter, and was hove to on the 21st, in lat. 29° 01′, lon. 129° 37′, as also on the 23d and 24th, near lat. 30°, lon. 124° E.; and was off Saddle Island, near the mouth of the Yang-tsz' River, from the 27th to 30th, the wind having then veered to S. E., with squalls and continued bad weather. The Saratoga's barometer reached its lowest, 29·60, at noon of the 24th, in lat. 29° 28′, lon. 128° 17′, with the wind at E. N. E., and afterward veering to S. S. E., as with the steamships of the squadron bound to Loo Choo. We have no observations from points nearer to the right border of the cyclone.

We have next the report from the master of the U. S. ship Supply, then lying in the harbor of Napha, Loo Choo, in lat. 26° 12′ N., lon. 127° 43′ E. This shows that the anterior barometric wave of the cyclone had reached Napha at noon of the 12th, barometer 30·02 inches. It then slowly subsided, with winds from easterly points, until it reached 29·84, on the night of the 17th. The wind freshened, and was strong on the 18th, with a continued fall of the barometer. On the 19th and 20th

the gale was blowing from the N.E. quarter, with increasing violence. Its greatest force was on the 21st, when it had veered to the northward; the barometer 28·88 at 3 A. M., and 28·82 at noon, with a slight reaction at evening. On the 22d, at 3 P. M., it had settled to 28·74, the lowest point reached; from which it rose only to 28·83 at midnight, with improving weather. On the 23d and 24th the gale veered through east to S.E., and the barometer continued to rise. On the 20th it reached to 29·80, the ordinary height for July in that region, at which time the wind had veered to south, and the force of the gale was no longer felt. The fall and rise of the barometer here, as with the other ships, was attended with moderate fluctuations of some hours continuance, as is more or less common in other cyclones of large extent. The gale was violent at Napha, but not in the greatest force of hurricanes. It was observed "that even when the wind was piping loudest—when the water was whirled violently by in perfect sheets—the scud moved overhead at a remarkably slow rate, and the upper layer of clouds seemed scarcely to be stirred at all;" thus showing the very limited height of this vast cyclone. Its axial center, in passing Loo Choo, was nearest to Napha at about noon of 22d, at an estimated distance of about eighty miles.

In tracing the further progress of the gale towards the coast of China we are aided by the well kept log-book of the U. S. storeship Caprice, under Lt. W. L. Maury, during her stormy passage from Shanghai to Loo Choo. On the 17th of July the Caprice left the Woosung River and stood down the Yang-tsz for sea, with bar. at 29·71, the highest during the passage, and while anchored at night encountered a heavy ground swell from S.E. On the 18th working out of the river with wind at S.E.; bar. 29·67, and heavy swell continued. On the 20th the wind veered from E.S.E. to N.E. by N., increasing in strength, with heavy swell from S.E. to E.S.E., lat. 31° 33′, lon. 123° 18′ E.; ship preparing for the gale. On the 21st, gale from N.E. by N., veering to N.E.; lat. 29° 30′, lon. 124° 42′; bar. 29·40. On 22d, gale from N.E. to E., increasing in force, with heavy sea; bar. 29·25; ship hove to at 7 P. M. During the 23d and 24th the gale continued with great violence (about lat. 28° 30′, lon. 124° 20′ E.), veering through east to S.E. The barometer reached its minimum, 29·16, from 1 to 3 P. M. of 24th. After this period the gale was found to abate, during successive days, but with considerable fluctuations of force, until the first day of August, in lat. 28° 35′, lon. 125° 09′ E., when the wind, which had now veered to the southward, became moderate, and the barometer rose to 29·69 inches.

These phenomena, now presented in an abridged form, may be regarded as of much scientific and practical interest. It does

not appear that the Caprice was at any time nearer to the axis of the cyclone than about one hundred and fifty miles. The gradual influence of the cyclone upon her barometer, from the time of sailing, was unusually steady. The entire range of the instrument during a period of seventy-two hours, from 3 A. M. of 22d to the same hour of 25th, while in the heart of the storm, was scarcely more than one-tenth of an inch, or between 29·27 and 29·16 inches. Its greatest depression occurred near 1 P. M. of the 24th, and is deemed to indicate the nearest approach of the cyclonic axis, as it passed the ship. Its nearest approach to the Supply, at Loo Choo, appears to have been near 3 P. M. of 22d; which is earlier by seventy hours. Hence, the rate of the advance of the cyclone during this period, for the distance of little more than two hundred nautical miles, appears only equal to *three nautical miles per hour*. At an earlier period the advance of the storm may have been more rapid; as has been seen in other cyclones when distant from their places of recurvation.

The absence of any winds *except those from the eastern board* with the several ships whose reports we have noticed, would probably lead many navigators and meteorologists to infer that this gale was not a cyclone, but a wind moving in the manner of a general current; and such inference might seem confirmed on finding that this peculiarity of direction occurred over a region nearly equal to ten degrees of latitude. But the characteristic movements of the barometer and the coincident cyclonic changes in the direction and strength of the winds from that side of the meridian, as also the earlier action and subsequent changes of the heavy swell, which often ran on a course different from the incumbent wind, as found at the several ships, are sufficient proofs of the rotary character of this extensive gale. Moreover, the steady direction and velocity of the gale as felt by the steamships on the 20th and 21st was such that if moving directly onward in the manner of a current it should have reached the U. S. ship Caprice, and the coast of China, in about eight hours: and yet, some fifty or sixty hours are found to have elapsed, ere this amount of progress was accomplished.

But while the cyclonic character of this gale is thus fully established, it will doubtless gratify our readers to know that we have one series of direct observations of the northerly and westerly winds of the cyclone, on the *left* side of the path of its axis, and hence veering inversely, through the west and south. These observations were procured by Lieut. William L. Maury from the log-book of the British schooner Earnest, which encountered the gale, in sailing from Hong Kong towards Shanghai.

This vessel was standing through the Formosa Channel when she encountered the first winds of the cyclone, from N. N. W., near lat. 25° 30′ N., lon. 120° 46′ E., barometer down to 29·40,

which wind, while increasing to a severe gale, enabled her to clear the north end of Formosa, and meeting a heavy sea from N.E., while thus drawing nearer to the center-path of the gale. On the 23d the gale increased; the barometer at noon at 29·20; the wind veering from N.N.W. to N.N.E., as she approached the storm's center. At midnight the aneroid had fallen to 28·50, and the 24th began with a hurricane from N.N.E., and high sea. At noon, gale less violent; weather looking very unsettled; at 1 P. M. wind W.N.W.; aneroid 28·30 and still falling: at 3 P. M. calm!! [vessel in the southern side of the axial area of the gale.] At 3.30 P. M. wind increasing and bearing to S.W.; 5 P. M. gale S.W.; 5.30, blowing a hurricane: 6 P. M., hurricane from south, increasing; scudding under bare poles; aneroid 24·14: [vessel now behind the storm's center and running across its path]. At 7 P. M. gale had veered to S.E. The gale continued from the S.E. on the 25th; the vessel scudding towards her destined port. On the 27th the aneroid stood at 29·63, in lat. 30° 07′, lon. 122° 46′·8; the winds still fresh and weather squally.

It thus appears that the Earnest took the gale, in force on the night of the 21st, from N.N.W., at a distance of perhaps ninety miles to the left of the line on which the storm was approaching. But pushing northeastward, in order to clear Formosa and the small islands in its vicinity, she steered almost directly for the approaching vortex of the gale, thus changing its direction from N.N.W. to N.N.E., the latter being the normal direction of the anterior part of the gale, on its center-path. When the axis had passed and the direction of the gale thus became southerly, the vessel was able to run to the northward, on her desired course, which carried her across the axis-path, into the second *right hand quadrant* of the gale. This brought the wind to the southeast, as with the other ships, which were then in the same quadrant of the cyclone.

To what distance the force of this cyclone might have been traced on the left or southerly side of its track we are unable to determine; but this was doubtless less than the extension on the right side of its axis line, as is seen in most cyclones, north of the equator. As regards the entire breadth of its path, we learn from the report of sailing master Conover to Commodore Perry, "that on the 26th and 27th of July it blew most terribly upon the coast, from Hong Kong to Shanghai; scattering and wrecking the unwieldy Chinese junks and sending many a poor fisherman to his long home." Its further course, over the great alluvial plain of China and the adjacent waters of the Yellow Sea, and the subsequent recurvation of its path, cannot be determined from observation. Its axis-path on the Pacific, as indicated by the foregoing reports, marked A, is seen on the accompanying storm-chart of the North Pacific Ocean.

The phenomena of this great cyclone seem fruitful in instruction to mariners and meteorologists, and present points of practical interest on which we cannot now dwell. Without regard to its slow rate of progression, it may be noticed that the phases of the barometer and winds presented in the extensive region on the right of its axis-path, are in accordance with those found in the two right-hand quadrants of the great cyclones which so often sweep over the United States and the North Atlantic, in the northeasterly course. Thus, during the W.N.W. progression of the cyclone, in lower latitudes, we have seen that the winds of its two right-hand quadrants were from the *eastern* board, veering *to the right* as the storm went onward. In like manner our cyclones, in pursuing a *northeasterly* course after their recurvation in lower latitudes, present us, in their two right-hand quadrants, with winds veering towards the right on the horizon; but which, in consequence of this inversion in the course of the storm, commence in a southern quarter, and thus veer *westward*, as the storm advances in its course over the places of observation which are on the right of its axis-path. Such cases are often presented; of which our navigators have much experience in crossing the Atlantic.

*Cyclones of the China Sea and Gulf of Tonquin.*—A cyclone of some intensity was experienced by the flag-ship of the expedition from the 2d to the 4th of August, 1854, in the harbor of Krem-Ling-Moon, near Macao. It set in at N.E., and veered through east and S.E. to S. and S.S.W.; the barometer being at its lowest point, 29·26 inches, on the 3d of August. These phases of the wind show the ship to have been under the two right hand quadrants of the gale, and not very far from its axis.

I have placed on the chart the track of a cyclone encountered by the American ship Panama, in the China Sea, in October, 1831; which storm had previously passed over the Philippine Islands and proved very destructive at Manilla.

The track of the cyclone encountered by H. M. ship Raleigh near the Bashee Islands, in August, 1835, is also indicated. This storm subsequently visited Macao and Canton, in great violence; and, with that of the Panama, was noticed in this Journal.* The sketch of its place and progress on the 5th and 6th days of August, with some correction in the track of one of the ships, is here subjoined. [See opposite page.]

The Raleigh, as appears from the logbook since published by Col. Reid, left Macao Roads on the first of August, sailing on the track shown on our sketch, which was engraved previous to the first publication of Col. Reid's work on storms. On the 4th, the ship encountered northeasterly and northerly winds, with a

* This Journal, [1], vol. xxxv, p. 201.

falling barometer; which increased to a heavy typhoon at N.N.E.; veering to N.E. and E.N.E.; bar. at 8 A. M., 29·60; noon, 29·45; 8 P. M., 29·60; midnight, 29·04, and typhoon increasing in violence. At 3 A. M. of Aug. 5th it had veered to E.S.E., still increasing; bar. 28·50, and falling. At 5 A. M. typhoon blowing from S.E.; and at 6.30 A. M., bar. falling rapidly from 28·30 to 28·20, commenced throwing overboard the guns and shot. At 8 A. M., the force of the hurricane still increasing; and at 9.30 A. M. the ship went over; the masts and bowsprit went by the board, and the ship righted, with four feet of water in the hold, in lat. 20° 44′, lon. 119° 18′ E. At 1 P. M. of the 5th the typhoon was blowing from S.S.E. and had moderated a little. From 6 to 7 P. M. more moderate, but strong gusts of wind and a heavy sea from the southward.




It appears by the direction and phases of the wind that the Raleigh was on the right or northerly side of the center-path of the cyclone, and that at the crisis of the gale the center passed

very near to the ship; as is shown, also, by the great fall of the barometer and the intensity of the gale at that period.

At Macao, the typhoon was experienced in great force, eighteen or twenty hours *later* than with the Raleigh. A valuable series of observations was here taken of the barometer, in the typhoon; the lowest being 28·08 inches, at 1.20 A. M. of 6th of August. This great depression shows the center or vortex to have passed near Macao.

At Canton, about sixty miles north of Macao, the gale began on the evening of the 5th, with northerly winds, and continued through the following day. At midnight following the 5th the barometer had fallen to 29·37; but its further fall in the night was not observed. At 5 A. M. it had risen to 29·34; and at 8 A. M. of 7th, it had risen to 29·94 inches. The wind, during the typhoon, veered from N. through N.E. and E. to S.E.

The ship Lady Hayes sailed from Macao before the gale, and first encountered it about thirty-five miles from land. She ran off southeastward with a north wind and tremendous swell from eastward, and at 8 P. M. of 5th the wind began to veer westward, blowing as hard as ever till midnight, and drawing round to the south. It continued blowing hard from this quarter until noon of the 6th. It is seen by the veering of the wind that this ship was on the left or southerly side of the path of the gale's axis. A British schooner also encountered the gale on the 5th of August, in lat. 18° 02′ N., lon. 115° 50′ E. The ship American Levant in coming up the China Sea, ran into the rear of this cyclone, and thus made a fine run into port at Linteri.

From these data, the course of the storm appears to have been N. 72 W.; and its rate of progression about seventeen miles an hour: the line on which its axial center appeared to advance is marked A, B, C, on the sketch. If circles having a radius of one hundred and sixty nautical miles be drawn around the two points B and C, these will comprise, severally, the areas of chief violence in this hurricane at the successive periods, 9 A. M. of 5th and 2 A. M. of 6th of August. But the cyclone must have extended, of less force, very far beyond these approximately estimated limits.

More detailed accounts of the phenomena of this typhoon may be found in vols. xxxv and xxxvi of this Journal for 1839; where will also be found notices of the typhoon of the Panama, before referred to, and of another which visited Canton on the 3d of August 1832; another on the 23d of September 1831; both of which had crossed the China Sea; also, of four successive typhoons which were encountered in the China Sea by the convoy under H. M. S. Swift, in the China Sea, on June 19th, July 2d, July 8th, and July 17th, 1797; in the second of which, the Swift is supposed to have foundered. The tracks of these

storms are well illustrated by that of the Raleigh's typhoon, and I omit, therefore, the close grouping which a delineation of them would require on the chart.

The ship Harkuru left Hong Kong for London, May 16th, 1854, and returned to port under jury-masts on the 11th of June. At noon of May 20th the ship was in lat. 16° 22′ N., lon 113° E.; wind E. N. E.; barometer falling in the evening, with lightning at south. The master close-reefed his sails, but still stood on: bar. still falling, and at 2 A. M. 20th sea getting cross and high. At 10 A. M. the gale increased to a hurricane, with a fearful cross sea: ship hove to under bare poles, in lat. 15° N., lon. 112° 20′ E. P. M. bar. down to 28·50, and still falling; at 2 P. M., the ship lying with her yard-arms in the water, her topmasts were cut away. Soon after it fell flat calm; the barometer down to 27·70. At 3 P. M. the wind flew to N. W., veering to W., and S. W., blowing with tenfold violence. At 6 P. M. the fury of the typhoon moderated, the barometer rising; the gale veering to S. W. and S. At 8 P. M. of the 21st the weather had moderated; wind S. to S. E.

The master of the Harkuru should have been wiser than to have pitched into the heart of this typhoon, ahead of its vortex. For fuller accounts I am indebted to Commander John Rodgers, lately in charge of the U. S. Surveying Expedition in the N. Pacific, who was then running up the China Sea in the steamer Hancock, and falling into the rear of this cyclone, made a fine run under its westerly and southerly winds, keeping at a safe distance from its vortex.*

In vol. xxxv of this Journal, p. 220, I have shown that at Canton, on the southern coast of China, the semi-annual changes of the monsoons are found to occur in April, and about the last days of September; varying somewhat in different years. Typhoons frequently cross the China Sea from May to October, and sometimes in other months, on routes corresponding, in direction, to those of the West Indies and the lower latitudes of the Atlantic, and with like characteristics. That inquiring old voyager, Dampier, states that on the coast of Tonquin the typhoons are expected in the months of July, August, and September. We know that these are deemed to be hurricane months in the lower latitudes of the Atlantic, east of Yucatan, but no special connection with the above periods of change in the monsoons is here indicated. Dampier says, that in these typhoons "the wind comes on fierce and blows very violent at N.E. twelve hours, more or less: and when the wind begins to abate it dies away suddenly, and falling flat calm, it continues so an hour, more or less, when the wind comes about to the S.W. and it

* For full accounts see this Journal, vol. xxiii, 1857, p. 205.

blows and rains as fierce from thence, as it did before from the N.E., and as long." A better description of a violent cyclone, as observed on its center-path in the lower latitudes north of the equator, could hardly be given.

*On the Relations of Cyclones to the Monsoons.*—In the Asiatic seas, as elsewhere, the judgment of the navigator is often misguided by the loose and inaccurate statements which are found in various authorities. Thus, it is said that gales or hurricanes rarely occur in these seas, except at the change of the monsoons; or at the period of the equinoxes. These assumed axioms are greatly erroneous:—as the inspection of the storm chart will suffice to show.

The actual relations of the cyclones to the monsoons and local winds of the Asiatic seas are of much interest, and merit a careful examination. It is quite remarkable that the monsoons should be found to have little, if any control or influence, as regards the regular courses and development of the cyclones. This may show the predominance of cosmical laws and influences, over those apparently opposing conditions which are so extensively presented in these alternating winds.

The longitudinal extent of the westerly monsoons, parallel to, and on both sides of, the equator, appears to be far greater than has been recognized by most writers. In the northern hemisphere, these counter-winds of the true trades extend from the east coast of Africa, near lon. 45° E., at least to lon. 175° E., in the central Pacific. The proper trade wind, appears to consist of a comparatively thin stratum of aerial current, moving upon the ocean surface, and is distinguished by its inclination towards the equator. On this stratum there is ordinarily imposed another current, probably of greater depth and volume, into which the trade wind ultimately merges, and which also moves westward in the trade-wind latitudes, but generally inclines *from* the equator; as is shown by the rain-clouds and squalls which it carries, and by the direction of translation imparted to the cyclones which it embodies. This important wind-current, so little recognized by most writers except as a monsoon-wind, frequently alternates with or displaces the true trades, and still more frequently it displaces the westerly monsoon, as a surface wind; especially to the east of Sumatra. Thus, the "southwest monsoon" of the China Sea and the western Pacific, which extends to the shores of Japan, and far eastward into the Pacific, is very often displaced from the surface by the subsidence of the main current of south-easterly wind; more especially in the regions near the Asiatic coast.

*Universality of the Law of Storms.*—The law of rotation and progression in storms as developed on the Atlantic Ocean, which was substantially discerned by the present writer in the

year 1821, is essentially cosmical or world-wide in its origin and application. This soon became apparent, in examining the accounts of gales which are found in the voyages of Cook, Vancouver, and others, in the several oceans and climatory zones of our globe. Hence, the polar relations of the phenomena presented, are necessarily changed in the southern hemisphere; where in all our comparisons, south must be substituted for north; east and west remaining the same.

This similarity of polar relations in the winds of the two hemispheres, and the corresponding influences on the barometer which are shown by the opposite cyclonic changes of these winds, are virtually recognized in Capt. P. P. King's account of his surveying expeditition in the southern hemisphere, about the year 1826, as is seen in his sailing directions. The more complete and satisfactory evidence of this cosmical system, or law, of cyclonic action, which is derived from a series of extensive geographical observations, made in the paths of storms in the southern hemisphere, has since been furnished in the several works of Reid, Thom, and Piddington.—The latter author has also investigated many storms of the Sea of Bengal, and the Indian Ocean, and has noticed various gales or typhoons of the China Sea.

*A Typhoon in February in the Trade Winds of the North Pacific.*—At noon of February 3d, 1853, the Annie Buckman, sailing for Canton, was in lat. 12° 30′ N., lon. 129° 16′ E., with barometer at 29·75 and a double reefed topsail breeze from northeast. Between this time and the 9th the vessel was subject to a very violent typhoon; during which both the direction of the wind and the course of the vessel went round the compass, by the north, west, and south, to the N. E. quarter on the 9th. At noon of this day the vessel was in lat. 18° 09′ N., lon. 127° 25′ E.; bar. 29·80, and of the few entries given, the lowest was 29·25, at 4 P. M. of Feb. 7th; wind then from the westward, and increasing soon after to its greatest violence.—Capt. Barber states that in twenty years of navigation, in all oceans, he had not encountered a hurricane so violent. A full account of the gale was furnished by him to the officers of the Japan Expedition. Its path is indicated on the chart.

*Cyclones at the Bonin Islands.*—On the 25th of October, 1853, the U. S. ship Plymouth encountered a typhoon at Port Lloyd; in lat. 27° 05′ N., lon. 143° 11′ E.; in which one officer and a boats crew, then absent from the ship, were lost. According to the master's report to Commodore Perry, it commenced with squalls of wind from E. S. E., under which the barometer began to fall. "At 9 P. M. it fell calm; and continued so for little less than an hour, when the wind came out again suddenly from N. W., with terrific violence, blowing if anything still harder than from E. S. E.; barometer when lowest 28·97; at

which it arrived very rapidly; and when it commenced rising it did so in the same manner."—This cyclone had evidently completed its recurvation when passing over the Bonin Islands.

On the 28th of October, 1854, another severe typhoon passed over Port Lloyd, where the U. S. ship Vincennes, of the Surveying Expedition, was then lying at anchor; in which the barometer fell to 28·43 inches. I have a communication in which this storm is ably described, by Commodore John Rodgers, who had charge of the expedition, and Anton Schönborn, Assistant Astronomer, and the series of barometric phenomena and their relations to the cyclonic winds are very fully presented. In its recurvation, the center of this gale went round to the westward of Port Lloyd; as indicated by the successive phases of the winds and barometer.

*Cyclone of the U. S. Steamship Mississippi.*—In returning from Japan, the U. S. ships Mississippi and Southampton left Simoda on the 1st of October, 1854; steering for the Sandwich Islands. On the 2d they encountered a swell from S. E.; and on the 6th and 7th, when near lat. 36° N., they were overtaken by a cyclone, which increased, with the Mississippi, to the force of a hurricane. On the 6th the Southampton had the cyclonic wind strong from the eastward, in lon. 146° 43′ F., veering in the night to S. S. E. On the morning of the 7th it had veered to S. S. W.; and at 9 A. M. it was moderate and became variable in direction. At noon in lat. 37° 08′, lon. 147° 55′ E., the barometer was lowest, and the wind had settled to a gale at N. W.

The Mississippi at noon of 5th, was in lat. 34° N., lon. 149° E.; and the barometer had fallen from 30·11 to 30·04; the wind veering from N. E. to E. S. E., increasing to 6 in its force. At noon of 6th was in lat. 35° 21′, lon. 151° 33′ E.; the wind gradually veering to S. S. E. The barometer fell gradually from 30·02 to 29·71; and at 9 P. M. the force of the gale had increased to 9: topsails close reefed.—Oct. 7th, during first twelve hours, gale S. S. E., veering towards south. "The square sails were taken in, and the ship hauled up to the S. E., to avoid the center of the typhoon, which was evidently approaching from the S. W." At noon, gale increasing, lat. 35° 59′, lon. 153° 47′ E.; and barometer had fallen to 29·39. At 1 P. M. gale S. by W., 10; bar. 29·29:—2 P. M., S. S. W., 11; bar. 29·17, being its lowest. At 3 P. M., hurricane S. W., 12; bar. 29·21. From noon "until 4 P. M., the wind was blowing with the force of a hurricane;—flattening the sea and filling the air with spoon drift;—subsiding then to a heavy gale." At 6 P. M., gale W. S. W., 10; barometer 29·45:—10 P. M. West; barometer 29·60.—On the morning of the 8th the gale stood at W. S. W., abating in force.

It is apparent that the right-hand quadrants of this cyclone passed over both ships; and that the Southampton in her more

westerly position, was nearest to the axis path, and yet found the gale but moderately violent. This may be ascribed to the greatly dilated condition of that portion of the gale;—a condition not uncommon in great cyclones when passing through the temperate latitudes; and which perhaps may have its chief origin in the region where the recurvation of the storm path occurs. For in the change of course at this period, the winds of the eastern portion of the cyclone find an earlier and shorter transit into the recurvated path of the lower temperate latitudes, than can be found by the opposite winds of the western side, which are now left to pursue a wider circuit.

On arriving at the Sandwich Islands, Lt. W. L. Maury of the Mississippi procured an extract from the log-book of the American whale ship George Howland; which vessel encountered the gale on the 8th of October, near lat. 46° N. On this day, at 8 A. M., the wind hauled to S. S. W., and increased to a gale. Lat. 46° 18′ N., lon. 165° 50′ E. At 4 P. M., wind E. (E. S. E. true,) blowing a heavy gale. At 9 P. M. the gale died away suddenly, and came down from S. W. On the 9th the wind veered to the west; a heavy cross sea; and on the morning of 10th the gale was fresh from N. W. At noon moderate; lat. 44° 36′, lon. 173° 20′ E.

This further tracing of the cyclone increased the desire for observations from its path in the lower latitudes, which seemed unattainable. But the London Nautical Magazine for February, 1855, contains a full report from Capt. Briard, of the English brig Gifford. The vessel was sailing from San Francisco for Shanghai; and on 3d of October was in lat. 25° 32′ N., lon. 137° 48′ E., with a fresh wind from N. E., increasing at night, with squalls and rain: ship veering N. W. by N.; barometer fluctuating from 29·80. Oct. 4th, gale increasing, with rain; lat. 27° 40′, lon. 134° 10′ E., bar. 29·60. At 1 P. M. the bar. fell to 29·35; the gale increasing; and the Captain began to suspect he was edging gradually in with a typhoon; the wind then being east, and his course W. N. W. He decided on heaving to, "to allow the center of the cyclone to pass on ahead," and accordingly placed the ships head to N. N. E. At midnight, bar. 29·25; gale E. S. E.

October 5th, still lying to in the typhoon.—

| | | | | |
|---|---|---|---|---|
| At 4 A. M. | bar. | 29·20; | gale | S. E. |
| " 8 " | " | 29·15 | " | S. S. E. |
| " noon | " | 29·05 | " | S. S. E. |
| " 2 P. M. | " | 29·00 | " | S. by E. |
| " 4 " | " | 28·80 | " | South |
| " 8 " | " | 28·70 | " | S. S. W. |

Midnight " 28·70; blowing this day a furious typhoon; which at 4 P. M. carried away the bowsprit, foremast,

and maintopmast.—October 6th, at 1 A. M. the barometer began to rise; at 2 A. M. bar. 28·90; gale W. S. W., moderating a little. At 4 A. M. bar. 29·00; wind west by S.; 8 A. M. 29·10; noon 29·30; moderating fast, but still blowing a severe gale.

Capt. Briard thinks, that on the 4th, the cyclone was travelling N. W.; but, "that on the 5th, it recurved to the north; as we had the heaviest of it when the center bore N. W." We are certainly indebted to him for a good account of this typhoon, previous to and at the time of its recurvation. On comparing his report with those of the great cyclone of July, 1853, before noticed, I am led to infer that the southeast swell encountered by the U. S. ships on the 2d, was produced by the right-hand portion or border of the cyclone, while travelling northwestward.

I have received from the British Admiralty, through the kindness of Capt. A. B. Becher, R. N., the observations made, during the nearest passing of the cyclone, on board H. M. S. Winchester, then lying in Nagasaki roads, lat. 32° 44′ N., lon. 129° 46′ E. I consider this position as about three hundred miles to the northwest of the nearest portion of the axial line of the storm path, after the recurvation; with the great Island of Kiusiu intervening. At midnight, previous to the 5th of October, the weather was calm; the barometer 30·05: at noon of 5th it had fallen to 29·88, with the wind veering from E. N. E. to N. E., the true wind of the cyclone on this border; its force 4 to 3, with squally weather. In the afternoon the wind veered to the north, and the barometer fell to 29·80; near which it continued during the night, and throughout the next day; the wind nearly at north, varying in its force from 4 to 2; with a calm at 8 P. M. On the morning of the 7th, the wind came from N. N. W., force 3, and at noon the barometer had risen to 29·97; it attained a maximum of 30·06 in the following night.

We here find a depression of a quarter of an inch in the barometer, under the cyclonic winds which are normal to this place, which is wholly sheltered by high lands from the original force of these winds. The phenomena do not differ essentially from those which are often found near the western border of the cyclones of the United States, when in a like relative position. The last two accounts, will serve to show the approximate position which I have assigned to the axis path of the track, on the chart at and near the time of its recurvation.

From these various reports, we may estimate the rate of the cyclone's advance, from the probable position of its center at noon on the 3d, to that on the 4th of October, at about seventeen nautical miles per hour:—from thence to noon of 5th, from ten to twelve miles per hour: from 5th to 7th, at twenty-two miles per hour; and from 7th to 9th at about forty miles per hour.

If to this we add one diameter of its area, as found in the time and rate of its transits, at the places of our earliest and latest observations, respectively, we may consider its known path as extending more than four thousand nautical miles.

*Reindeer's Cyclone, July*, 1850.—The American ship Reindeer was dismasted in a furious hurricane on the 19th of July 1850, in lat. 18° 30′ N., lon. 139° E.; about twelve hundred miles from the coast of China. She ran with bare poles, under the easterly winds of the cyclone; thus nearing its vortex, till the barometer had fallen to 58·85, when the wind veered to S. S. E., in a perfect blast; the ship broached to, and the masts soon went overboard.

With the knowledge of storms we now possess our ships ought not to be thus disabled, in open sea.

*The Freak's Typhoon of May 1st*, 1850.—The English brig Freak fell in with this cyclone in lat. 19° 28′ N., lon. 138° 44′ E., with the wind at E. by S. varying to E. by N., and the brig ran westward, with an increasing gale. At midnight the master began to suspect that he was approaching the vortex of a cyclone that was travelling to the northwest, and at 1 A. M., May 2d, he hove to, on the starboard tack, to allow it to pass him. It continued blowing a hurricane, and at noon the wind became E. N. E., with barometer at 29·22. Between 2 and 3 P. M., the fore topmast was broken off by the force of the wind; which at this time was beyond description. At 3·50 P. M. the barometer had fallen to 28·87, its lowest point. The wind from noon continued to haul northward, its greatest strength being from about N. E. by N., and the master thus found to his surprise, that he was in the northwest quadrant of the cyclone and on the left side of its center-path; it having already recurved to the northward and eastward. From 4 P. M. the barometer began to rise and the force of the gale to decrease.

The easterly winds of this cyclone having veered by the north, the master's inference that the recurvation in its course took place during the time his vessel was in the gale, appears correct; the center of the vortex having recurved southward and eastward of the vessel's place. The full account may be seen in the London Nautical Magazine for 1851, p. 273–275.

*Ladrone or Marian Islands.*—These islands lie near lon. 146° E., and are subject to hurricanes, for which the inhabitants prepare, by lashing down and securing their houses. They are expected in the months of June, July, and August: also, in December and January. The island of Guam, lat. 13° 26′ N., was visited on the 23d of Sept. 1855, by a typhoon of the most violent character. More than eight thousand persons were left without a house or roof to protect them from the fury of the storm.

*Cyclone of the J. N. Gosler, May*, 1855.—The American ship ship J. N. Gosler, from San Francisco for Hong Kong, experienced a heavy typhoon on the 28th of May 1855, in lat. 16° 40′ N., lon. 147° 45′ E.; nearly two thousand miles from the Chinese coast. She carried away sails, spars, &c.; and was abandoned on the 30th, with nine feet of water in the hold. The officers and crew succeeded in reaching the Marian Islands, in their boats.

*Strong's Island and Ascension.*—Mr. John T. Gulick of the Sandwich Islands, in the year 1852 visited several of the Micronesian Islands, near the equator, in company with the missionaries who then settled at these islands. At Strong's Island (Ualan) in lat. 5° 12′ N., lon. 163° E., they were informed by King George, the principal chief, that some years previous, the island had been visited by a hurricane which wholly destroyed the bread fruit trees and caused a famine which nearly depopulated the island. He described it as blowing first from one quarter of the heavens, and then from another. At Ascension Island, (Bonabe) which is about three hundred miles distant, in a west-northwest direction, a similar account was received.

*Cyclone of the Austerlitz, Nov.* 1851.—The new clipper Witchcraft arrived at Hong Kong on the 3d of December, from California, with loss of main-mast-head and all the topmasts. She experienced a typhoon on the 13–14th of Nov., in lat. 22° 40′ N., lon. 150° E.

About the same period, in lat. 19° 48′ N., lon. 159° E., the American ship Austerlitz was totally dismasted. The chain plates were torn from her sides, and her hull otherwise much injured, and the vessel was soon afterwards abandoned.

It cannot be doubted that the Austerlitz and Witchcraft fell, successively, into the heart of this cyclone. We have thus two points established in its track, which are distant from each other about five hundred and thirty nautical miles. These positions show its course to have been N. 71° W.; or W. N. W., nearly. The position of the Austerlitz is more than two thousand five hundred miles from Hong Kong; and is somewhat nearer to the Sandwich Islands.

*Kingsmill Islands and Gilbert Archipelago.*—These islands, situated on and near the equator, near lon. 175° E., were visited by a ship of the U. S. exploring expedition under Capt. Wilkes. Variable winds from the northward and westward prevail, from October to April; and they have violent gales from the southwest. According to Kirby, who was taken off the islands, these storms are typhoon-like; and last three or four days. The westerly sides of the islands receive most damage; and both land and trees are swept away.

*Radak Islands.*—These islands are scattered between 6° and 11° north latitude, and lon. 168° to 173° E. Capt. Kotzebue ascertained that hurricanes of great violence sometimes occur, in September and October; and the natives always anticipate with dread the recurrence of those months.

*The Japan's Typhoon.*—In December 1832, the Japan, a new ship, encountered a severe hurricane in lat. 13° N., longitude about 160° west. This position is nearly on the meridian of the most western of the Sandwich Islands.

*The Sandwich Islands.*—At the Sandwich Islands, lat. 19° to 22° N., lon. 155° to 160° W., the cyclones which occur are not commonly of great severity; although, the native huts are sometimes unroofed or destroyed. The *kona*, or southerly wind, by which the trade wind during part of the year is much interrupted, may be referred, at least in part, to those cyclones which find their center-path northward of the islands, or which complete their recurvation in that region. The easterly gales, which accord nearly with the trade wind in their direction, indicate an axis-path which lies southward of the islands. The actual presence, or influence of a cyclone, may commonly be determined by the indicative oscillations of the barometer.

The absence of intense violence, in any of the cyclones which visit this group, may possibly be due to their geographical position. But it is equally probable, that this qualified exemption may result from a diversion of the course of the central vortex of the cyclone, occasioned by the great height and compact form of Hawaii, the most southeastern of these islands. For the group lies in almost a direct line, which is parallel to the ordinary course of cyclones in the lower latitudes; being, from the summit of Mauna Kea to the center of Kauai, N. 61° west. A cyclonic vortex, if moving previously on this line, would be displaced by the eastern angle of Hawaii; which island has an area of nearly four thousand square miles, a portion of which rises far above the upper horizon of the cyclones; and at two points reaches an elevation of nearly fourteen thousand feet. The protection, or partial diversion of course thus occasioned, must extend to the high but smaller islands which lie to the leeward in the same track.

*Cyclone of the Lark.*—The Lark, an American barque from Canton for Valparaiso, met a severe gale on the 23d of Sept. 1843, in lat. 15° N., lon. 138° 40′ west. The Lark also encountered a violent typhoon at an earlier date, when off the island of Formosa.

*Cyclones of the Eastern Pacific.*—For the sake of brevity, I pass over several accounts of violent cyclones which have been found between the Sandwich Islands and the southern coasts of Mexico and Central America. The occurrence of hur-

ricanes in this part of the Pacific is by no means unfrequent; and the cases I have before quoted in this Journal, are instructive to navigators. The omitted notices are contained in the Appendix to the Account of the Japan Expedition, already referred to. The sketches of these storm tracks are found with others, on the small chart of the North Pacific illustrating this article.

If these imperfect notices shall contribute, in any degree, to the safety and success of our ships and commerce, it will be a grateful reward for the attention and labor which this important subject has at any time required.

New York, Sept. 6, 1856.

---

## Art. III.—*Reply to Dr. F. A. Genth's remarks on the Minerals of the Canton Mine;* by Charles Upham Shepard.

The duty of affording the mineralogical reader a fair opportunity of judging of the nature of several minerals, very cursorily treated of in a mining report published last year, has been forced upon me by the statements respecting them, which have appeared in this periodical.

Of one of these minerals, Prof. Dana observes in his Third Supplement to his Mineralogy (2nd Series, vol. xxii, p. 251, Sept. 1856): *Cherokine*, a species as yet imperfectly described by the author: crystallizes like pyromorphite, but has the color of carbonate of lead. Gr. = 4·8. Stated to contain phosphate of alumina and zinc. [The form given, near to pyromorphite, would suggest the improbability that the mineral is a phosphate of a sesquioxyd with zinc, unless a pseudomorph.—J. D. D.]

Now the words of the report (p. 14,) are these. "Cherokine.—This is another species, before unknown, which largely contains oxyd of lead. It resembles white lead ore (carbonate of lead) in its color, but possesses the crystalline form of pyromorphite, while it contains phosphate of alumina and oxyd of zinc, and further differs from plumbo-resinite, by containing much less water, and a specific gravity of only 4·8."

But this substance has unfortunately met with a graver misconception from Dr. Genth, in his paper, entitled "Contributions to Mineralogy" published in the last number of this Journal (p. 145), which is the less easily accounted for from the fact, that the second part of my Treatise on Mineralogy, published last December, contained the following (p. 407):

"*Cherokine.* In slightly acuminated hexagonal prisms, somewhat drusy; botryoidal and massive. Color white, with a tinge of pink interiorly; the outside being often greenish or bluish-white. Lustre adamantine. Several indistinct cleavages, parallel to the prismatic axis. Frac-

ture uneven. Translucent. H. = 3·75 . . . 4. G. = 4·81. Heated in a tube, affords a little moisture, becomes milk-white and opaque. B. B., becomes yellow while hot, phosphoresces slightly, swells up and melts with effervescence into a yellow gobule (a slight yellow areola, surrounding the mass); on cooling does not crystallize, but is perfectly glassy, colorless and semi-transparent. In powder, moistened with sulphuric acid, does not tinge the flame of the candle, green. With soda effervesces violently, is brick-red while hot, yellow when cold, affording an abundance of lead globules and a large ring, yellow while hot, but white on cooling. Heated with nitrate of cobalt, it affords the deep blue, characteristic of alumina. Soluble in nitric acid without effervescence. It is chiefly phosphate of lead; but also contains hydrate or phosphate of alumina (or both) and oxyd of zinc. It differs from plombgomme by containing much less water, and possessing an inferior specific gravity. Found in seams and cavities with pyrites, chalcopyrite, quartz and staurotide at the Canton mine in Cherokee Co., Ga.; and named from the county in which it occurs."

Dr. Genth's heading is, "*Cherokine is Pyromorphite.*" He states that he has received "a genuine specimen" of my mineral from F. W. Harris, and gives these few words as my description of it: "It resembles white lead ore (carbonate of lead) in its color, but possesses the crystalline form of pyromorphite, while it contains phosphate of alumina and oxyd of zinc, and further differs from Plumbo-resinite by containing much less water," etc. He then goes on to observe that after a special search for water, alumina and oxyd of zinc, he could find neither; that before the blowpipe, it melted easily, and that the globule assumed on cooling a polyhedral form.

I think it must appear under these circumstances, a wholly gratuitous assumption, that Mr. Harris placed in his hands a genuine specimen of the cherokine; and since crystals of pyromorphite having a thin white coating of some mineral, are common at the mine, it seems to me most probable, that this was the substance mistaken for cherokine.

Dr. Genth declares *Harrisite to be a pseudomorph of Copper-glance after Galena*, prefacing his observations upon the point, with the following statement: "Early in this year I examined the Canton mine, and collected part of the material and data for the following investigation. I am also indebted to Dr. W. C. Daniell, Prof. Julien, M. Deby and W. F. Harris, Esq., for minerals from this mine."

As favorable to the view taken by Dr. Genth, he would convey the impression, that harrisite occurs in a part of the ore-stratum where it is accessible to atmospheric changes, and that in descending, it gives place to ordinary galena. He says, "no harrisite has ever been observed below 141 feet in depth, and it has given place to unaltered galena. It may be found again however, if the ore-stratum of the Canton mine or a similar one,

should be developed where the atmospheric influences have been favorable to such changes."

Now the facts in the case are these. At 90 feet from the top of the ground, the ore-bearing schists begin to lose their tendency to decomposition. Galena is here visible in a perfectly fresh condition, between the laminæ of the slate and upon the cross-joints of the rock. At a depth of 116 feet, every vestige of alteration has disappeared. Here commences, in the form of a mere thread, the dropper-vein that carries the harrisite. It descends, gradually enlarging out to fifteen or twenty inches in thickness, at an angle of between 30 and 40°, when it is suddenly pinched off, and wholly disappears, in the 141 foot level. Fresh galena has accompanied the metalliferous stratum, exterior to the dropper, for the whole course of its descent, and continues onward in increasing quantity, below the point of its termination. But no galena or any other ore of lead, or even a single mould or impression of any lead ore has been detected within the dropper. On the other hand, no harrisite to my knowledge, has been found in the rock, exterior to the dropper-vein.

Dr. Genth recognizes the force of the argument from the perfect cleavage visible in every fragment of the harrisite, against the view he has undertaken to support: but cites the pseudomorphs of gypsum after anhydrite which have the perfect cleavage of the latter, together with some other instances of the like nature. To this, perhaps, it is sufficient to observe, that it is at best evidence only of a negative character; for our knowledge of pseudomorphism is still very imperfect, and further investigations may modify much our present views. Add to this, the opposite facts of wulfenite after galena, wolfram after scheelite, and gypsum and polyhalite after salt unattended by the easy cleavages which his hypothesis demands.

Dr. Genth attaches weight also to the consideration, that the harrisite has a similar proportion of silver to the galena of the Canton mine. But the content of silver constantly varies in the galena of the mine. I have found a variation of from 30 to 56 oz., in 2000 lbs. of the ore; and Mr. Pratt in his valuable communication upon this locality, published in the same number of this Journal, observes that "the percentage of silver in the galena of any mine varies with the position of the lead ore, and my examination shows, that in this view, it increases with its approach to the north wall. In different determinations, I have found, from 0·1 to 0·3 p. c., equal to 32 and 96 oz. per ton of the ore," (p. 413). Besides the presence of silver in an ore of copper, is a fact by no means unfrequent.

The locality of copper-glance after galena in Saxony, cited on the authority of Breithaupt may be a correct determination, the attending circumstances being such as to support the conclusion.

But it is important to notice that Dr. Genth is half inclined to admit Scheerer's variety with a cubical cleavage, found at Tellemark in Norway, as a genuine species; which certainly well explains an observation he makes upon harrisite:—"The eminent cleavage of this pseudomorph in the form of the original mineral has for a long time perplexed and kept me in doubt, whether, it might not be a good species after all, but the more carefully I have examined the specimens in my possession, and those of the Canton mine, the more have I become convinced that it is a pseudomorph." The results of this examination and the grounds of his conviction, have been presented and commented upon, above.

My mention of plumbo-resinite at this locality meets the following pointed criticism:—"*Shepard's Plumbo-Resinite from the Canton mine is Cyanosite.* I am indebted (observes Dr. G.) to W. F. Harris, Esq., who had the advantage of Prof. C. U. Shepard's *own* mineralogical determinations for a genuine specimen of what the latter in his report on the Canton mine calls Plumbo-resinite."

It is wholly and entirely an error to say, that Mr. Harris had any other means of knowing what I had called plumbo-resinite, than could be gathered from the few words in which it was mentioned in the report. I had not detected the mineral when at the mine; but only after my return from it, to Charleston; and I have never communicated either by letter or specimens, with the gentleman mentioned, upon the subject. The specimens employed in my determination are now arranged in my mineralogical cabinet at Amherst, Mass., where any one who may choose to examine them, will easily form an opinion how unlikely it must have been, that I could ever have committed the mistake of confounding such a substance, with the common blue-vitriol incrustations of the Canton mine.

The next of my minerals reëxamined by Dr. Genth is the *Hitchcockite.* The mining report does little besides announcing its existence and the reason of its name. It mentions it as a white, earthy crust or shell, whose composition was that of a hydrated phosphate of alumina, with oxyd of zinc; and it seemed most natural in an economical report, to include it along with automolite under the general heading of *ores of zinc*, not supposing that any candid mind would possibly infer therefrom, that I regarded it, as a working ore of that metal. Indeed I supposed that my language would rather convey the idea, that the oxyd of zinc was an unimportant, if not an accidental, constituent of the substance.

But to show what I regarded as a more satisfactory account of the mineral, I here subjoin my description of it, drawn from my Mineralogy (p. 401):

"*Hitchcockite.* Massive. In coatings and botryoidal. Sometimes concentric like allophane. H.=2·75...3. Gr.=2·909. Color white, greyish, bluish and rarely with a tinge of green. Lustre vitreous to adamantine. Transparent to translucent.

"Heated in a glass tube, it emits much moisture. B.B., phosphoresces brightly, turning of a pale yellow color, while hot. Infusible. Moistened with nitrate of cobalt and ignited, it assumes a very rich blue color. In the state of powder, when moistened with sulphuric acid and heated, it tinges the flame of the candle green. With borax it readily melts, attended by effervescence, into a transparent glass, which on cooling, has a faint tinge of blue. With soda, it quickly changes to a deep yellow color, attended by the reduction of oxyd of zinc, and by a deposit of its oxyd upon the charcoal, which has a yellow color while it is hot. Soluble without effervescence, in warm nitric or hydrochloric acid. By full ignition, in the state of powder, it loses 29·45 p. c.; and is inferred to be a hydrated phosphate of alumina, with oxyd of zinc. Occurs in thin crusts, like hyalite, upon the joints of quartzy mica-slate, at the Canton copper- and lead-mine, in Cherokee county, Ga. It is associated with marcasite, pyrites, galena, chalcopyrite, automalite and staurotide. Named after Dr. Hitchcock, of Amherst College."

I will now introduce Dr. Genth's statement concerning the substance he has examined; and thus place before the reader an opportunity of judging, whether he has here occupied himself with my mineral, or with something else.

"On my late visit to the Canton mine," he observes, "I procured a considerable number of specimens of this interesting *new* mineral, and the following are the results of my examinations.

"With a good magnifier only it can be observed that this mineral has a crrystalline structure. It usually occurs in botryoidal concretions or small mamillary incrustations. Color white, yellowish, bluish and reddish white; powder white. Lustre subresinous, subvitreous and dull. Translucent.

"It has an argillaceous odor when breathed upon. Brittle; fracture uneven. H. = 4·5. Sp. gr. (at 20° Cels.) about 4·014.

"Before the blowpipe shrinks, but does not fuse; with cobalt solution, gives a fine azure blue mass; with carbonate of soda on charcoal, yields metallic lead incrustations. Dissolves both in boiling nitric and chlorhydric acids, more readily in the latter. The following are the results of my analyses:

| | I. | II. | | | |
|---|---|---|---|---|---|
| "Insoluble, - - | 1·11 | 0·48 p. c. | | | |
| Chlorine, - - | not determined. | 0 04 " | | | |
| Carbonic acid, - | not determined. | 1·98 " | contains oxygen | | 1·44 |
| Phosphoric acid, | 18·74 | 18·74 " | " | " | 10·50 |
| Oxyd of lead, - | not determined. | 29 04 " | " | " | 2·11 |
| Alumina, - | 24·69 | 25·54 " | " | " | 11·91 |
| Sesquioxyd of iron, | 0·68 | 0·90 " | " | " | 0·27 |
| Lime, - - | 1·49 | 1·44 " | " | " | 0·69 |
| Water, - - | 21·65 | 20·86 " | " | " | 10·55" |
| | | 99·02 | | | |

Dr. Genth gives the calculated percentage of the pure mineral thus:

| | | |
|---|---|---|
| $3PbO$, | 334·8 | 30·44 p. c. |
| $6Al_2O_3$, | 308·0 | 28·01 " |
| $3PO_5$, | 214·0 | 19·46 " |
| $27HO$, | 243·0 | 22·09 " |
| | 1099·8 | 100·00 |

Now if the reader will take the trouble to compare the amorphous structure of the Hitchcockite, with the crystalline character of Dr. Genth's mineral, but more especially, if he will notice the widely different hardness, gravity and blowpipe properties of the two, he will be satisfied, that Dr. Genth has not examined the Hitchcockite, at all. And still farther, if he will compare Dr. Genth's results with the descriptions of the plumbo-resinite, he will find nothing in them, really inconsistent with the supposition, that he has mistaken an impure specimen of my plumbo-resinite for the Hitchcockite! Even his analyses accord with this view, as will appear from the following results of the researches of Damour, upon the plumbo-resinite of Huelgöet:

| | |
|---|---|
| Phosphoric acid, | 8·06 |
| Oxyd of lead, | 35·10 |
| Alumina, | 34·32 |
| Peroxyd of iron, | 0·20 |
| Lime, | 0·80 |
| Chlorid of lead, | 2·27 |
| Sulphuric acid, | 0·30 |
| Water, | 18·70 |
| | 99·75 |

The mineralogist will hardly need to be reminded, in this connection, that plumbo-resinite does not rank among the most indubitable of our species. It is even doubtful whether it is any thing more than a variable mixture of Fischerite or Hitchcockite, with Pyromorphite: while the disputed Cherokine stands, perhaps, upon the same precarious footing, though it appears for the present, to possess a set of properties, not reconcilable with the normal varieties of plumbo-resinite.

Dr. Genth calls in question my discovery of *Lanthanite* at Canton, in these rather remarkable words: "Prof. C. U. Shepard states (Report on the Canton Mine), that he has observed this mineral at the Canton mine; he does not inform us, however, what induces him to take the pink-colored crystals for lanthanite. I have not been able to procure a specimen of it, and also did not succeed in finding any indications of minerals containing cerium or lanthana, from the decomposition of which the lanthanite could have been formed."

It was natural to have supposed, that the simple mention of a mere mineralogical curiosity, was all that could have been looked for in an economical report. I have, however, had reference to

the subject more fully, on page 400 of my Mineralogy; and will now only add, that I verified the coincidence of the mineral with lanthanite, in crystalline form, hardness, blowpipe properties and solubility with effervescence in nitric acid, while at the mine, and in the presence of my friend, Rev. W. F. Harris. Moreover, specimens still remaining, may be inspected by any one, who visits my cabinet. I would hope that these statements will inspire a degree of confidence in my determination, in the minds of those, who may have been led to doubt its correctness, from the consideration that Dr. Genth was unable to procure a specimen of the substance, and "did not succeed in finding any indications of minerals containing cerium or lanthana, from the decomposition of which, the lanthanite could have been formed."

In conclusion, I have only to observe, that although it is much to be desired, in notices of new minerals and new localities, that the greatest circumspection should be observed, still something perhaps may not unreasonably be allowed in mitigation of a certain amount of inadequacy and imperfection in these first announcements, since it is better to publish, occasionally, novelties in science, than to retain specimens upon the shelves of our cabinets for too long a time, unexamined and undescribed: for even a hint on the road to discovery will often stimulate to research and bring new inquirers into the field, whereby the ends of true science are sure to be promoted, although it may now and then prove less satisfactory to the ambition of the first observer, who fails in monopolizing the undivided merit of a discovery. But a little humility and love of truth will ever be a sufficient compensation for such trifling losses.

The time has come moreover, when to establish a species in mineralogy on a perfectly secure basis, is attended with greater difficulty than formerly. The easily recognized species have long ago been described. Accident, it is true, may from time to time, develop those which are as well pronounced as any; but it will not be strange if many minerals, really distinct in nature, will demand the most thorough sifting on the part of many observers, in order to bring out their characteristic differences. For one, I shall ever hold myself ready to engage in any such researches, whatever may be their ultimate success; though I may perhaps be pardoned for hoping, that they may meet a juster appreciation than my late attempts in this way have had the good fortune to experience.

## Art. IV.—*On a Modified form of Ruhmkorff's Induction Apparatus;* by E. S. Ritchie.

The Induction Apparatus made by Ruhmkorff and described by Du Moncel is probably familiar to many of your readers. By it is obtained a spark of three-fourths of an inch through the atmosphere. Mr. Hearder has described in the London Philosophical Magazine, (Nov. and Dec. 1846,) certain improvements by which he has lengthened the spark to three inches.

The great difficulty experienced by him was in obtaining sufficient insulation between one stratum of the wire and the next above or below it, the entire thickness of the helix—including wire and insulation—being only about half an inch, and a tension of electricity sufficient to throw a spark three inches existing between the outer and inner strata.

Mr. Stöhrer has adopted the plan of dividing the coil into three divisions, thus lessening the difficulty; still, great danger exists of the spark passing which would ruin the helix.

I have endeavored to obviate this by winding the coil the *entire thickness as it progresses.* I commenced with a glass tube or bobbin, laying the first course on a cone at as great an angle as the wire could be conveniently laid—say about 50°. The diameter at the tube was about two and one half inches and the greatest diameter three and one half inches, the length of the cone being nearly half an inch. When the stratum was laid, and cemented by resin and bees-wax, a ring of thin vulcanized rubber was stretched over and cemented, the wire passed down to the glass cylinder, and this wire covered also by rubber; then another stratum was laid in the same manner;—that is, the coil is built up precisely as a *cop* is laid by a mule-spinner. The advantages are that the wire in each conical layer is very short, and only a slight tension can exist between them.

With a helix thus made, with less than 7,000 feet of wire, I obtained a spark of two and one quarter inches; and with one since constructed on the same principle, with 30,000 feet of wire, differing only so far as I found necessary to enable me to wind the helix by a machine which I constructed for the purpose, I have obtained sparks over six inches long.

I have constructed the condenser with oiled silk, with very thin gutta percha, and with paper of different thicknesses; but find tissue paper varnished and used double, according to Mr. Bentley's plan, the best. The surfaces used in the instruments above described are respectively about thirty and seventy-five square feet. I have used all the interuptors alluded to by the writers above mentioned, but prefer one which I have made thus: The anvil is a wire or small rod of platinum secured in a plate

by a binding-screw; over this a rod of platinum is secured in the same manner to a spring which presses them together; another spring loaded acts like a hammer upon the end of the first spring, to separate the platinum rods. A ratchet wheel presses down this spring hammer, and allows it to recoil and strike the other spring. By this the interruption is more instantaneously made, and the distance to which the platinum rods are separated easily regulated. This point appears to be of importance. The spark is lessened if the platinum rods are separated farther than actually to break their contact. The usual primary helix of large wire and the interior bundle of iron wires are placed within the glass tube.

In my last instrument, I used a tube closed at the top, more effectually to cut off the passage of the current from one end to the other, through the primary helix or iron wires. I have used a Bunsen's battery of four to six cells; four give the spark of as great length, but a few more cells increases the volume. I have applied a battery of eighteen cells and also a plate battery of fifty-six pairs without endangering the coil. The instrument is undoubtedly capable of being greatly increased in size and power.

Boston, May 2, 1857.

---

## Art. V.—*Caricography;* by Prof. C. Dewey.

(Continued from vol. xix, p. 256, Second Series.)

No. 250. *Carex Douglasii*, Boott, in Hook. Fl. Bor.-Amer.

Spica oblonga composita, interdum dioica; spiculis multis 8–14 ovatis densè aggregatis supernè squamo-bracteatis, *distigmaticis;* fructibus ovali-lanceolatis bifidis vel bidentatis margine ciliatis, squamam lanceolatam castaneam non-aequantibus.

Culm scarcely a foot high, erect, bright green, leafy towards the base but naked above; spike compounded of many ovate spikelets, 8–14, closely aggregated above, less so below, and the lowest sometimes branched, sometimes all pistillate and stamens on another plant; stigmas two; fruit ovate-lanceolate, plano-convex, rostrate, bidentate, subscabrous on the margin, and a little shorter than the lanceolate and tawny scale.

West of Fort Pierre, Nebraska Ter.; collected by Dr. F. V. Hayden in his important geological explorations there. These specimens are not quite so large or the spikes so long as those mentioned by Dr. Boott from the northwest coast and Rocky Mountains. This species, like *C. Richardsoni*, R. Brown, has found a habitation far south of the one originally discovered.

No. 251. *C. Boottiana*, Bentham.

Spicis dioicis cylindraceis oblongis basin attenuatis squamaceo-bracteatis singulis cum squamis oblongis obovatis brevi-mucronatis, infernè attenuatis sparsiflorisque, fructibus *tristigmaticis* oblongis obovatis obtusis ore integris, scabro-villosis, squama paulo minoribus brevioribusque.

Culm 6–12 inches high, erect, with short leaves towards the base, and radical linear-lanceolate rough, leaves much longer than the culm and bright green; a single staminate spike oblong, cylindric, attenuated below, on one culm, and a similar pistillate spike on another, each with a scale-like bract at the base and loose-flowered, with oblong and obovate scales short-mucronate, and all reddish purple with a narrow white edge, and pale green keel; stigmas three; fruit oblong, obovate, hairy or woolly with entire orifice, and shorter and narrower than the scale.

Louisiana, Drummond, and Alabama, Peters. This is a very distinct species. My specimens were collected February 27th, 1857, at Moulton, Ala., by T. M. Peters, Esq. They were in full blossom, the fruit being young but distinct, and were communicated by Dr. H. P. Sartwell, the well-known friend of Caricography.

No. 252. *C. lævi-conica*, Dew.

Spicis distinctis; staminiferis 2–3, cylindraceis angustis, infima sub-pedunculata, cum squamis lanceolatis arctis; pistilliferis 2, interdum 3, cylindraceis erectis oblongis sub-densifloris folio-bracteatis, infima brevipedunculata vaginata, *tristigmaticis*; fructibus oblongis conicis teretibus vix inflatis obtusè terminatis bifurcatis vel raro bidentatis ore obliquis, in maturitate laevibus obsolete striatis gracilibus, squama ovata lanceolata longioribus vel aequantibus; culmo erecto gracili basin foliato sub-bipedali laevigato glabro.

Culm erect, often near two feet high, smooth, leafy towards the base; leafy bracts under the fertile spikes and surpassing the culm; staminate spikes 2 or 3, slender, cylindric, the lowest short-pedunculate, and all with close lanceolate scales; pistillate spikes 2, sometimes 3, oblong, cylindric, erect, leafy-bracteate, somewhat loosely flowered, the lowest with a short sheath; stigmas three; fruit oblong, tapering, slender, scarcely inflated and ending abruptly, bifurcate, oblique at the orifice, smooth and obsoletely striate in maturity and graceful; pistillate scale ovate and lanceolate, shorter than or equalling the fruit.

On the Big Sioux, Nebraska Ter.; Dr. F. V. Hayden. This plant is too unlike the Vesicariæ tribe, especially in the fruit and scale, to belong to it. It has considerable resemblance to *C. lævigata*, Smith, but is far unlike in the staminate spikes as well as in the fruit and other particulars. I can not trace it among

the newer species of Dr. Boott, and consider it not before described.

No. 253. *C. Meekii*, Dew.

Spica ovata composita; spiculis ovatis 6–10, in capitulo fusco arctè aggregatis, infima interdum subremota, in apicem staminiferis; fructibus *distigmaticis* inflato-convexis acuminatis bifidis margine subscabris, squama ovata cuspidata paulo brevioribus; culm setiformi, foliis angustis brevibus.

Culm 3–8 inches high, slender, erect, smooth, aggregated in tufts, leafy towards the base; leaves few, narrow, sheathing, often much shorter than the culm; spike formed of many ovate spikelets, 6 to 10 or more, collected into a head, the lowest sometimes a little separated, all pistillate below; stigmas two; fruit ovate, tapering into a bifid beak, flat or concave on the inner side, a little shorter than the scale which is ovate and cuspidate.

Near White River, Nebraska Ter.; Dr. F. V. Hayden. This species has a slight resemblance to *C. Hoodii*, Boott, but is much smaller and less robust, and too setaceous-like in its culm and leaves.

Named in honor of F. B. Meek, the friend and associate of Dr. Hayden in the exploration of the Mauvaises Terres or Bad Lands, of Nebraska Ter.

*Note.* In addition to the Carices above described and those mentioned in vol. xviii, pp. 102–4, Dr. Hayden collected the following in Nebraska Territory.

*C. cristata*, Schw.; *C. blanda*, Dew.; *C. filiformis*, Good.; *C. hystericina*, Willd.; *C. vulgaris?* Fries; *C. cephaloidea*, Dew.; *C. scirpoides*, Schk.; *C. ampullacea*, Good.; *C. tenera*, Dew.; *C. arctata*, Boott; *C. Hookerana*, Dew., before found in Arctic America; *C. setacea*, Dew.; *C. monile*, Tuck.; *C. scoparia*, Schk.; *C. petasata*, Dew., before found in Arctic America; *C. obtusata*, Lilj.; *C. festiva?* Dew., found before in high northern latitudes, and *C. curta*, Good.

The collection of Nebraska Carices therefore contains sixty species; of these, four are new, and three have not before been found in the United States.

ART. VI.—*The Self-sustaining power of the Gyroscope analytically examined;* by Maj. J. G. BARNARD, A. M., Corps of Engineers, U. S. A.

AFTER reading most of the popular explanations of the above phenomenon given in our scientific and other publications, I have found none altogether satisfactory. While, with more or less success, they expose the more obvious features of the phenomenon and find in the force of gravity an efficient cause of horizontal motion, they usually end in destroying the foundation on which their theory is built, and leave an effect to exist *without a cause;* a horizontal motion of the revolving disk about the point of support is supposed to be accounted for, while the descending motion, which is the first and direct effect of gravity (and without which no horizontal motion can take place), is ignored or supposed to be entirely eliminated. Indeed it is gravely stated as a distinguishing peculiarity of rotary motion, that, while gravity acting upon a non-rotating body causes it to descend vertically, the same force acting upon a rotary body causes it to *move horizontally*. *A tendency to descend* is supposed to produce the effect of an *actual descent;* as if, in mechanics, a mere tendency to motion ever produced any effect whatever without that motion actually taking place.

Whatever 'mystification' there may be in analysis—however it may hide its results under symbols unintelligible save to the initiated, it is most certain that the greater portion of the physical phenomena of the universe are utterly beyond the grasp of the human mind without its aid. The mind can—indeed it *must*—search out the inducing causes, bring them together and adjust them to each other, each in its proper relation to the rest; but farther than that (at least in complicated phenomena) unaided, it cannot go. It cannot *follow* these causes in all their various actions and re-actions and at a given instant of time bring forth the results.

This, analysis alone can do. *After* it has accomplished this, it indeed usually furnishes a clue by which to trace how the workings of known mechanical laws have conspired to produce these results. This clue I now propose to find in the analysis of rotary motion as applied to the gyroscope.

The failure in most attempts at popular explanation arises, it appears to me, *first*, in attempting to account for that which *is not true*, viz., an absolute self-sustaining power in the rotary disc in which all vertical motion is ignored; secondly, in making what is only a particular and extreme phase of rotary motion, an *isolated phenomenon*, and in seeking causes for it without reference to the general laws of that motion.

The analysis I shall present, so far as determining the equations of motions is concerned, is mainly derived from the works of Poisson (vide "Journal de l'Ecole Polytech." vol. xvi—Traité de Mécanique, vol. ii, p. 162). Following his steps and arriving at his analytical results, I propose to develop fully their meaning, and to show that they are expressions not merely of a visible phenomenon, but that they contain within themselves the sole clue to its explanation: while they dispel all that is mysterious or paradoxical, and, in reducing it to merely a "particular case" of the laws of "rotary motion," throw much light upon the significance and working of those laws.

Although not unfamiliar to mathematicians, it may not be uninteresting to those who have not time to go through the long preliminary study necessary to enable them to take up with Poisson this special investigation; or whose studies in mechanics have led them no farther than to the general equations of "rotary motion" found in text books, to show how the particular equations of the gyroscopic motion may be deduced.

In so doing I shall closely follow him; making however some few modifications for the sake of brevity and of avoiding the use of numerous auxiliary quantities not necessary to the limited scope of this investigation.

The general equations of rotary motion are (see Prof. Bartlett's "Analytical Mechanics" Equations (228), p. 170):

$$\left.\begin{aligned} C\frac{dv_z}{dt}+v_x v_y(B-A)&=L_1\\ B\frac{dv_y}{dt}+v_x v_z(A-C)&=M_1\\ A\frac{dv_x}{dt}+v_y v_z(C-B)&=N_1 \end{aligned}\right\} \quad (1.)$$

In the above expressions the rotating body (of any shape) $A\,B\,C\,D$ (fig. 1) is supposed retained by the *fixed* point (within or without its mass) $O$. $Ox$, $Oy$ and $Oz$ are the three co-ordinate axes, *fixed in space*, to which the motion of the body is referred. $Ox_1$, $Oy_1$, $Oz_1$, are the three *principal axes* belonging to the point $O$, and which, of course, partake of the body's motion. The position of the body at any instant of time is determined by those of the moving axes.

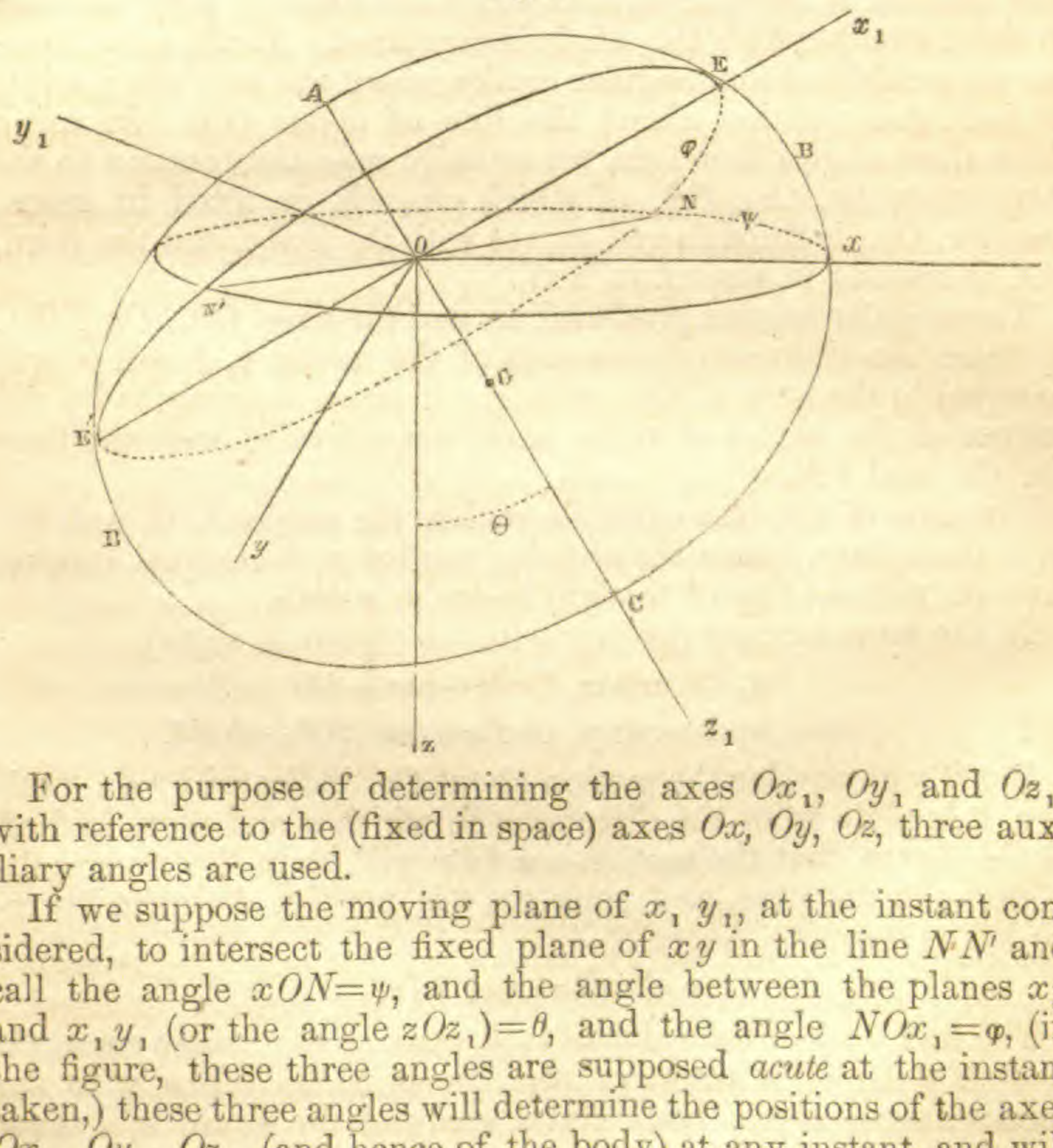
$A$, $B$ and $C$ express the several "moments of inertia" of the mass with reference, respectively, to the three principal axes $Ox_1$ $Oy_1$ $Oz_1$; $N_1$, $M_1$ and $L_1$ are the moments of the *accelerating forces*, and $v_x$, $v_y$, $v_z$, the *components of rotary velocity*, all taken with reference to these same axes.

Like lineal velocities, velocities of rotation may be decomposed —that is, a rotation about any single axis may be considered as

the resultant of components about other axes (which may always be reduced to three rectangular ones): and by this means, about whatever axis the body, at the instant we consider, may be revolving, its actual velocity and axis are determined by a knowledge of its components $v_x$, $v_y$, $v_z$, about the principal axes $Ox$, $Oy$, $Oz$,, these components being, as with lineal velocities, equal to the resultant velocity multiplied by the cosine of the angles their several rectangular axes make with the resultant axis.

As the true axis and rotary velocity may continually vary, so the components $v_x$, $v_y$, $v_z$, in equations (1) are variable functions of the time.

Fig. 1.




For the purpose of determining the axes $Ox_1$, $Oy_1$ and $Oz_1$, with reference to the (fixed in space) axes $Ox$, $Oy$, $Oz$, three auxiliary angles are used.

If we suppose the moving plane of $x_1$ $y_1$, at the instant considered, to intersect the fixed plane of $xy$ in the line $NN'$ and call the angle $xON=\psi$, and the angle between the planes $xy$ and $x_1 y_1$ (or the angle $zOz_1$)$=\theta$, and the angle $NOx_1=\varphi$, (in the figure, these three angles are supposed *acute* at the instant taken,) these three angles will determine the positions of the axes $Ox_1$, $Oy_1$, $Oz_1$, (and hence of the body) at any instant, and will themselves be functions of the time; and the rotary velocities $v_x$, $v_y$, $v_z$, may be expressed in terms of them and of their differential co-efficients.

For this purpose, and for use hereafter in our analysis, it is necessary to know the values, in terms of $\varphi$, $\theta$ and $\psi$, of the co-

sines of the angles made by the axes $Ox_1$, $Oy_1$ and $Oz_1$ with the fixed axes $Oz$ and $Oy$.

These values are shown to be (vide Bartlett's Mech., p. 172)

$\cos x_1 Oz = -\sin\theta \sin\varphi$ $\quad$ $\cos x_1 Oy = \cos\theta \cos\psi \sin\varphi - \sin\psi \cos\varphi$

$\cos y_1 Oz = -\sin\theta \cos\varphi$ $\quad$ $\cos y_1 Oy = \cos\theta \cos\psi \cos\varphi + \sin\psi \sin\varphi$

$\cos z_1 Oz = \cos\theta$ $\quad$ $\cos z_1 Oy = \sin\theta \cos\psi$

The differential angular motions, in the time $dt$, about the axes $Ox_1$, $Oy_1$, $Oz_1$, will be $v_x dt$, $v_y dt$, and $v_z dt$. We may determine the values of these motions by applying the laws of composition of rotary motion to the rotations indicated by the increments of the angles $\theta$, $\varphi$ and $\psi$.

If $\theta$ and $\varphi$ remain constant the increment $d\psi$ would indicate that amount of angular motion about the axis $Oz$ perpendicular to the plane in which this angle is measured. In the same manner $d\varphi$ would indicate angular motion about the axis $Oz_1$; while $d\theta$ indicates rotation about the line of nodes $ON$. In using these three angles therefore, we actually refer the rotation to the three axes $Oz$, $Oz_1$, $ON$, of which one, $Oz$, is fixed in space, another, $Oz_1$, is fixed in and moves with the body, and the third, $ON$, is shifting in respect to both.

The angular motion produced around the axes $Ox_1$, $Oy_1$, $Oz_1$, by these simultaneous increments of the angles $\varphi$, $\theta$ and $\psi$, will be equal to the sum of the products of these increments by the cosines of the angles of these axes, respectively, with the lines $Oz$, $Oz_1$ and $ON$.

The axis of $Oz_1$ for example makes the angles $\theta$, $0°$ and $90°$ with these lines, hence the angular motion $v_z dt$ is equal (taking the sum without regard to sign) to $\cos\theta d\psi + d\varphi$.

In the same manner (adding without regard to signs),

$$v_x dt = \cos x_1 Oz d\psi + \cos\varphi d\theta$$

and
$$v_y dt = \cos y_1 Oz d\psi + \cos(90° + \varphi) d\theta.$$

But if we consider the motion about $Oz_1$ indicated by $d\varphi$, positive, it is plain from the directions in which $\varphi$ and $\psi$ are laid off on the figure, that the motion $\cos\theta d\psi$ will be in the reverse direction and negative, and since $\cos\theta$ is positive $d\psi$ must be regarded as negative, hence

$$v_z dt = d\varphi - \cos\theta d\psi.$$

The first term of the value of $v_x dt$, $\cos x_1 Oz d\psi$ [since $\cos x_1 Oz$ $(= -\sin\theta \sin\varphi)$ is negative and $d\psi$ is to be taken with the negative sign] is positive. But a study of the figure will show that the rotation referred to the axis $Ox_1$, indicated by the first term of this value, is the reverse of that measured by a positive increment of $\theta$ in the second, and hence, (as $\cos\varphi$ is positive,) $d\theta$ must be considered negative. Making this change and substituting the values given of $\cos x_1 Oz$, $\cos y_1 Oz$, and for $\cos(90° + \varphi)$, $-\sin\varphi$, we have the three equations

$$\left.\begin{aligned} v_x\,dt &= \sin\theta\sin\varphi\,d\psi - \cos\varphi\,d\theta \\ v_y\,dt &= \sin\theta\cos\varphi\,d\psi + \sin\varphi\,d\theta \\ v_z\,dt &= d\varphi - \cos\theta\,d\psi \end{aligned}\right\} \quad (2.)^*$$

The general equations (1.) are susceptible of integration only in a few particular cases. Among these cases is that we consider, viz., that of a *solid of revolution* retained by a fixed point *in its axis of figure.*

Let the solid $ABCD$ (fig. 1) be supposed such a solid, of which $Oz_1$ is the axis of figure. It will be, of course, a principal axis, and any two rectangular axes in the plane, through $O$ perpendicular to it, will likewise be principal. By way of determining them, let $Ox_1$ be supposed to pierce the surface in some arbitrarily assumed $E$ point in this plane. Let $G$ be the center of gravity (gravity being the sole accelerating force). The moments of inertia $A$ and $B$ become equal, and equations (1.) reduce to

$$\left.\begin{aligned} C\,dv_z &= 0 \\ A\,dv_y - (C-A)\,v_z v_x\,dt &= \gamma a M g\,dt \\ A\,dv_x + (C-A)\,v_y v_z\,dt &= -\gamma b M g\,dt \end{aligned}\right\} \quad (3.)\dagger$$

in which the distance $OG$ of the point of support from the center of gravity is represented by $\gamma$, $g$ is the force of gravity, $M$ the mass, and $a$ and $b$ stand for the cosines $x_1, Oz$ and $y_1, Oz$ and of which the values are (p. 52)

$$a = -\sin\theta\sin\varphi, \qquad b = -\sin\theta\cos\varphi.$$

The first equation (3) gives by integration $v_z = n$, $n$ being an arbitrary constant; it indicates that the rotation about the axis of figure remains always constant.

Multiplying the two last equations (3) by $v_y$ and $v_x$ respectively and adding the products, we get

$$A(v_y\,dv_y + v_x\,dv_x) = \gamma M g(a v_y - b v_x)\,dt.$$

From the values of $a$ and $b$ above, and from those $v_x$ and $v_y$ (equations 2) it is easy to find

$$(a v_y - b v_x)\,dt = -\sin\theta\,d\theta = d.\cos\theta;$$

substituting this value and integrating and calling $h$ the arbitrary constant

$$A(v_y^2 + v_x^2) = 2\gamma M g\cos\theta + h \qquad (a)$$

* To avoid the introduction of numerous quantities foreign to our particular investigation and a tedious analysis, I have departed from Poisson and substituted the above simple method of getting equations (2.), which is an instructive illustration of the principles of the composition of rotary motions.

† See Bartlett's Mech. Equations (225) and (118) for the values of $L_1\ M_1\ N_1$: in the case we consider the extraneous force $P$ (of eq. 118) is $g$; the co-ordinates $x', y'$ of its point of application $G$ (referred to the axes $Ox_1$, $Oy_1$, $Oz_1$,) are zero and $z^1 = OG = \gamma$: cosines of $\alpha$, $\beta$ and $\gamma$ are $a$, $b$ and $c$: hence $L_1 = O$, $M_1 = \gamma a M g$, $N_1 = -\gamma b M g$.

Multiplying the two last equations (3), respectively, by $b$ and $a$ and adding and reducing by the value just found of $d.\cos\theta$ and of $v_z$, we get

$$A(b\,d\,v_y+a\,d\,v_x)+(C-A)\,n\,d.\cos\theta=O \qquad (b)$$

Differentiating the values of $a$ and $b$ and referring to equations (2) it may readily be verified (putting for $v_z$ its value $n$) that

$$d\,b=(v_x\cos\theta-a\,n)\,d\,t$$
$$d\,a=(b\,n-v_y\cos\theta)\,d\,t$$

and multiplying the first by $Av_y$ and the second by $Av_x$, and adding

$$A(v_y\,d\,b+v_x\,d\,a)=A\,n\,(b\,v_x-a\,v_y)\,d\,t=-A\,n\,d.\cos\theta.$$

Adding this to equation ($b$), we get

$A\,d.(b\,v_y+a\,v_x)+C\,n\,d.\cos\theta=O$, the integral of which is

$A(b\,v_y+a\,v_x)+C\,n\cos\theta=l$ ($l$ being an arbitrary constant). ($c$)

Referring to equations (2) it will be found by performing the operations indicated, that:

$$v_x{}^2+v_y{}^2=\sin^2\theta\frac{d\,\psi^2}{d\,t^2}+\frac{d\,\theta^2}{d\,t^2}$$

$$b\,v_y+a\,v_x=-\sin^2\theta\frac{d\,\psi}{d\,t}$$

Substituting these values in equations ($a$) and ($c$), we get

$$C\,n\cos\theta-A\sin^2\theta\frac{d\,\psi}{d\,t}=l$$

$$A\left(\sin^2\theta\frac{d\,\psi^2}{d\,t^2}+\frac{d\,\theta^2}{d\,t^2}\right)=2\,M\,g\,\gamma\cos\theta+h$$

If, at the origin of motion, the axis of figure is simply deviated from a vertical position by an arbitrary angle $\alpha$, in the plane of $xz$, and an arbitrary velocity $n$ is imparted about this axis alone; then $v_x$ and $v_y$ will, at that instant, be zero, $\theta=\alpha$, and the substitution of these values in equations ($a$) and ($c$) will determine the values of the constants $l$ and $h$.

$$h=-2\,M\,g\,\gamma\cos\alpha$$
$$l=C\,n\cos\alpha,$$

which substituted in the above equations, make them

$$\left.\begin{aligned}\sin^2\theta\frac{d\,\psi}{d\,t}&=\frac{C\,n}{A}(\cos\theta-\cos\alpha)\\ \sin^2\theta\frac{d\,\psi^2}{d\,t^2}+\frac{d\,\theta^2}{d\,t^2}&=\frac{2\,M\,g\,\gamma}{A}(\cos\theta-\cos\alpha)\end{aligned}\right\}\ (4.)$$

These together with the last equation (2) which may be written, (substituting the value of $v_z$)

$$d\,\varphi=n\,dt+\cos\theta\,d\,\psi \qquad (5.)$$

will, (if integrated) determine the three angles $\varphi$, $\theta$ and $\psi$ in terms of the time $t$. They are therefore the differential equations of motion of the gyroscope.

Let $NEE'$ (fig. 1) be a section of the solid by the plane $x_1\, y_1$. This section may be called the *equator*. $E$ being some fixed point in the equator (through which the principal axis $Ox_1$ passes), the angle $\varphi$ is the angle $EON$.

If $N$ is the *ascending node* of the equator—that is, the point at which $E$ in its axial rotation *rises above* the horizontal plane, the angle $\varphi$ must increase from $N$ towards $E$—that is, $d\varphi$ (in equation 5) must be positive and (as the second term of its value is usually very small compared to the first) the angular velocity $n$ must be positive. That being the case the value of $d\varphi$ will be exactly that due to the constant axial rotation $n\,dt$, augmented by the term $\cos\theta\, d\psi$, which is the projection on the plane of the equator of the angular motion $d\psi$ of the node. This term is an *increment* to $n\,dt$ when it is positive, and the reverse when it is negative. In the first case, the motion of the node is considered *retrograde*—in the second, *direct*.

The first member of the second equation (4) being essentially positive, the difference $\cos\theta - \cos\alpha$ must be always positive—that is, the axis of figure $Oz$, can never rise *above* its initial angle of elevation $\alpha$. As a consequence $\frac{d\psi}{dt}$ [in first equation (4)] must be always positive. The node $N$, therefore, moves always in the direction in which $\psi$ is laid off positively, and the motion will be direct or retrograde, with reference to the axial rotation, according as $\cos\theta$ is negative or positive—that is, as the axis of figure is above or below the horizontal plane. In either case the motion of the node in its own horizontal plane is always progressive in the same direction. If the rotation $n$ were reversed, so would also be the motion of the node.

If this rotation $n$ is zero, $\frac{d\psi}{dt}$ must also be zero and the second equation (4) reduces at once to the equation of the compound pendulum, as it should. Eliminating $\frac{d\psi}{dt}$ between the two equations (4) we get

$$\sin^2\theta\frac{d\theta^2}{dt^2}=\frac{2Mg\gamma}{A}\left[\sin^2\theta-\frac{C^2n^2}{2AMg\gamma}(\cos\theta-\cos\alpha)\right](\cos\theta-\cos\alpha).$$

The length of the simple pendulum which would make its oscillations in the same time as the body (if the rotary velocity $n$ were zero) is $\frac{A}{M\gamma}$.* If we call this $\lambda$ and make for simplicity

* The length of the simple pendulum is (see Bartlett's Mech., p. 252) $\lambda=\frac{k_1^2+\gamma^2}{\gamma}$

The moment of inertia $A=M(k_1^2+\gamma^2)$; hence $\frac{A}{M\gamma}=\lambda$.

$\frac{C^2 n^2}{2 A^2 g} = \frac{2\beta^2}{\lambda}$ the above equation becomes

$$\sin^2\theta \frac{d\theta^2}{dt^2} = \frac{2g}{\lambda}\left[\sin^2\theta - 2\beta^2(\cos\theta - \cos\alpha)\right](\cos\theta - \cos\alpha) \quad (6)$$

and the first equation (4) becomes

$$\sin^2\theta \frac{d\psi}{dt} = 2\beta\sqrt{\frac{g}{\lambda}}(\cos\theta - \cos\alpha). \quad (7.)$$

Equation (6) would, if integrated, give the value of $\theta$ in terms of the time; that is, the inclination which the axis of figure makes at any moment with the vertical; while eq. (7) (after substituting the ascertained value of $\theta$) would give the value of $\psi$ and hence determines the progressive movement of the body about the vertical $Oz$.

These equations in the above general form, have not been integrated;* nevertheless they furnish the means of obtaining all that we desire with regard to gyroscopic motion, and in particular that self-sustaining power, which it is the particular object of our analysis to explain.

In the first place, from eq. (6), by putting $\frac{d\theta}{dt}$ equal to zero, we can obtain the maximum and minimum values of $\theta$. This diff. co-efficient is zero, when the factor $\cos\theta - \cos\alpha = 0$, that is, when $\theta = \alpha$; and this is a *maximum*, for it has just been shown from equations (4) that $\theta$ cannot exceed $\alpha$. It will be zero also and $\theta$ a *minimum*,† when

$$\sin^2\theta - 2\beta^2(\cos\theta - \cos\alpha) = 0$$

or
$$\cos\theta = -\beta^2 + \sqrt{1 + 2\beta^2\cos\alpha + \beta^4} \quad (8.)$$

(The positive sign of the radical alone applies to the case, since the negative one would make $\theta$ a greater angle than $\alpha$.)

It is clear that ($\alpha$ being given) the value of $\theta$ depends on $\beta$ alone, and that it can never become zero unless $\beta$ is zero; and as long as the impressed rotary velocity $n$ is not itself zero (however minute it may be), $\beta$ will have a finite value.

Thus, however minute may be the velocity of rotation, it is sufficient to prevent the axis of rotation *from falling to a vertical position.*

The self-sustaining power of the gyroscope when very great velocities are given *is but an extreme case of this law.* For, if $\beta$ is very great, the small quantity $1 - \cos^2\alpha$ may be subtracted from the quantity under the radical (eq. 8) without sensibly altering its value, which would cause that eq. to become

$$\cos\theta = \cos\alpha.$$

* The integration may be effected by the use of elliptic functions: but the process is of no interest in this discussion.

† It is easy to show that this value of $\theta$ belongs to an actual minimum; but it is scarcely worth while to introduce the proof.

That is, when the impressed velocity $n$, and in consequence $\beta$ is very great, the minimum value of $\theta$ differs from its maximum $\alpha$ by an exceedingly minute quantity.

Here then is the result, analytically found, which so surprises the observer, and for which an explanation has been so much sought and so variously given. The revolving body, though solicited by gravity, *does not visibly fall.*

Knowing this fact, we may *assume* that the impressed velocity $n$ is very great, and hence $\cos\theta - \cos\alpha$ exceedingly minute, and on this supposition, obtain integrals of equations (6) and (7), which will express with all requisite accuracy the true gyroscopic motion. For this purpose, make

$$\theta = \alpha - u, \qquad d\theta = -du$$

in which the new variable $u$ is always extremely minute, and is the angular descent of the axis of figure below its initial elevation.

By developing and neglecting the powers of $u$ superior to the square, we have

$$\sin^2\theta = \sin^2\alpha - u\sin 2\alpha + u^2\cos 2\alpha \ *$$
$$\cos\theta - \cos\alpha = u\sin\alpha - \tfrac{1}{2}u^2\cos\alpha$$

substituting these values in eq. 6 we get

$$\sqrt{\frac{g}{\lambda}}\,dt = \frac{du}{\sqrt{2u\sin\alpha - u^2(\cos\alpha + 4\beta^2)}}. \ \dagger$$

$\beta$ having been assumed very great, $\cos\alpha$ may be neglected in comparison with $4\beta^2$, and the above may be written

$$\sqrt{\frac{g}{\lambda}}\,dt = \frac{du}{\sqrt{2u\sin\alpha - 4\beta^2u^2}}. \qquad (d)$$

Integrating and observing that $u = o$, when $t = o$, we have

* By Stirling's theorem,

$$f(u) = U + U'\frac{u}{1} + U''\frac{u^2}{1.2}, \text{ \&c.,}$$

in which $U$, $U'$, $U''$ &c. are the values of $f(u)$ and its different co-efficients when $u$ is made zero.

Making $f(u) = \sin^2(\alpha - u)$, and recollecting that $\sin 2u = 2\sin u\cos u$ and $\cos 2u = \cos^2 u - \sin^2 u$, we get the value of $\sin^2\theta$; and making $f(u) = \cos(\alpha - u) - \cos\alpha$ the value in text of $\cos\theta - \cos\alpha$ is obtained.

† Eq. 6 may be written

$$\frac{\lambda}{g}\frac{d\theta^2}{dt^2} = 2(\cos\theta - \cos\alpha) - 4\beta^2\frac{(\cos\theta - \cos\alpha)^2}{\sin^2\theta}.$$

By substituting the values just found, of $d\theta$, $\sin^2\theta$ and $\cos\theta - \cos\alpha$ and performing the operations indicated, neglecting the higher powers of $u$, (by which $\frac{(\cos\theta - \cos\alpha)^2}{\sin^2\theta}$ reduces simply to $u^2$) and deducing the value $\sqrt{\frac{g}{\lambda}}\,dt$, the expression in the text, is obtained.

$$\sqrt{\frac{g}{\lambda}}.t = \frac{1}{2\beta}.\text{arc}\left[\cos = 1 - \frac{4\beta^2 u}{\sin\alpha}\right]*$$

$$u = \frac{\sin\alpha}{4\beta^2}\left(1 - \cos 2\beta\sqrt{\frac{g}{\lambda}}.t\right)$$

or, (since $\cos 2a = 1 - 2\sin^2 a$)

$$u = \frac{1}{2\beta^2}\sin\alpha\sin^2\beta\sqrt{\frac{g}{\lambda}}.t \qquad (9.)$$

Putting $\alpha - u$ in place of $\theta$ (equat. 7) neglecting square of $u$, we get

$$\frac{d\psi}{dt} = \frac{1}{\beta}\sqrt{\frac{g}{\lambda}}.\sin^2\beta\sqrt{\frac{g}{\lambda}}.t \qquad (10)\dagger$$

from which, observing that $\psi = 0$, when $t = 0$

$$\psi = \frac{1}{2\beta}\sqrt{\frac{g}{\lambda}}.t - \frac{1}{4\beta^2}\sin\left(2\beta\sqrt{\frac{g}{\lambda}}.t\right) \qquad (11)$$

These three expressions (9), (10), (11), represent the vertical angular depression—the horizontal angular velocity—and the

* $\frac{du}{\sqrt{2u\sin\alpha - 4\beta^2 u^2}}$ may be put in the form $\frac{2\beta}{\sin\alpha}\cdot\frac{\frac{\sin\alpha}{4\beta^2}du}{\sqrt{2u\frac{\sin\alpha}{4\beta^2} - u^2}}$.

Call $\frac{\sin\alpha}{4\beta^2} = R$, and the integral of the 2d factor of the above is the arc whose radius is R and versed sine is $u$; or whose cosine is $R - u$; or it is R *times* the arc whose cosine $1 - \frac{u}{R}$ with radius unity. Substituting the value of R in the integral and multiplying by the factor $\frac{2\beta}{\sin\alpha}$ we get the value of $\sqrt{\frac{g}{\lambda}}$ t, of the text.

† In eq. (7) if we divide both members by $\sin^2\theta$, and, in reducing the fraction $\frac{\cos\theta - \cos\alpha}{\sin^2\theta}$, use the values already found and neglect the *square*, as well as higher powers $u$, (which may be done without sensible error owing to the minuteness of $u$, though it could not be done in the foregoing values of $dt$ and $t$, since the co-efficient $4\beta^2$ in those values, is reciprocally great, as $u$ is small) the quotient will be simply $\frac{u}{\sin\alpha}$.

Substituting the value of $u$ and dividing out $\sin\alpha$ we get the value of $\frac{d\psi}{dt}$ in the text.

The integral of $\sin 2\beta\sqrt{\frac{g}{\lambda}}\,t\,dt$ results from the formula $\int\sin^2\varphi\,d\varphi = \frac{1}{2}\varphi - -\frac{1}{4}\sin 2\varphi$, easily obtained by substituting for $\sin^2\varphi$, its value $\frac{1}{2} - \frac{1}{2}\cos 2\varphi$.

extent of horizontal angular motion of the axis of figure after any time $t$.*

The first two will reach their respective maxima and minima when $\sin\beta\sqrt{\frac{g}{\lambda}}t=1$ and $=0$; or when $t=\frac{\pi}{2\beta}\sqrt{\frac{\lambda}{g}}$ and $t=\frac{\pi}{\beta}\sqrt{\frac{\lambda}{g}}$. These values of $t$ in equation (11) give

$$\psi=\frac{\pi}{4\beta^2}. \qquad \psi=\frac{\pi}{2\beta^2}.$$

Hence, counting from the commencement of motion when $t$, $u$, $\frac{d\psi}{dt}$ and $\psi$ are all zero, we have the following series of corresponding values of these variables

$$t=\frac{\pi}{2\beta}\sqrt{\frac{\lambda}{g}},\ u=\frac{1}{2\beta^2}\sin\alpha,\ \frac{d\psi}{dt}=\frac{1}{\beta}\sqrt{\frac{g}{\lambda}},\ \psi=\frac{\pi}{4\beta^2}$$

which correspond to the moment of greatest depression, when $u$ and $\frac{d\psi}{dt}$ are maxima, and

$$t=\frac{\pi}{\beta}\sqrt{\frac{\lambda}{g}},\ u=0,\ \frac{d\psi}{dt}=0,\ \psi=\frac{\pi}{2\beta^2},$$

when, it appears ($u$ being the zero), the axis of figure has regained its original elevation and the horizontal velocity is destroyed.

All these values are (owing to the assumed large value of $\beta$) very minute. If we suppose the rotating velocity $n=100\pi$ or 100 revolutions per second, the maximum of $u$ (with an instrument of ordinary proportions) would be a fraction of a minute of arc, and the period of undulation but a fraction of a second.

Hence the horizontal motion about the point of support will be exceedingly slow compared with the axial rotation of the disk expressed by $n$.

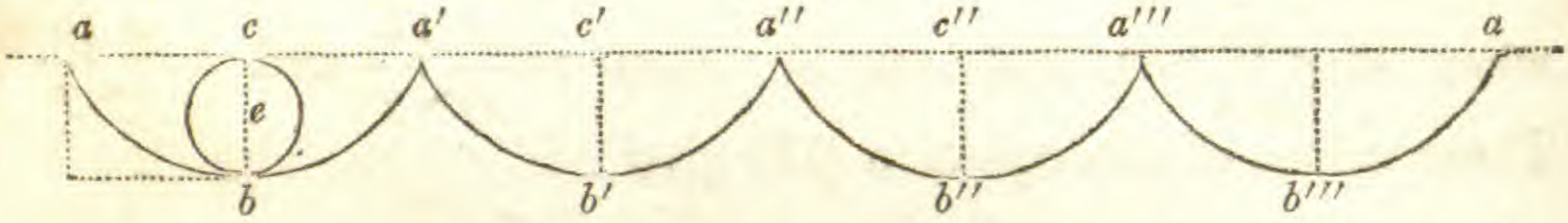
If, in equations (9) and (10), we increase $t$ indefinitely, we will find but a repetition of the series of values already found, they being recurring functions of the time.

We see then the revolving body *does not* in fact maintain a uniform unchanging elevation, and move about its point of support at a uniform rate, (as it appears to do). But the axis of figure generates what may be called a *corrugated cone*, and any

* The assumption that $\downarrow=0$ when $t$ is zero supposes that the initial position of the node coincides with the fixed axis of $x$. In my subsequent illustrations and analysis I suppose the initial position to be at 90° therefrom, which would require to the above value of $\downarrow$, the constant $\frac{1}{2}\pi$ to be added. The horizontal angular motion of the axis of figure is the same as that of the node.

point of it would describe an undulating curve (fig. 2) whose superior culminations $a$, $a'$, $a''$, &c., are *cusps* lying in the same

Fig. 2.




horizontal plane, and whose sagittae $cb$, $c'b'$, &c., are to the amplitudes $aa'$, $a'a''$, &c., as $\frac{\sin\alpha}{2\beta^2} : \frac{\pi}{2\beta^2} :: \sin\alpha : \pi$. If the initial elevation $\alpha$ is 90°, this ratio is *as the diameter to the circumference of the circle:* a property which indicates the *cycloid.*

Assuming $\alpha=90°$ and $\sin\alpha=1$, equations (9) and (10) will give, by elimination of $\sin^2\beta\sqrt{\frac{g}{\lambda}}t$,

$$\frac{d\psi}{dt}=2\beta\sqrt{\frac{g}{\lambda}}u \qquad dt=\frac{d\psi}{2\beta\sqrt{\frac{g}{\lambda}}u},$$

substituting this value in eq. ($d$) we get

$$d\psi=\frac{2\beta u\,du}{\sqrt{2u-4\beta^2u^2}}=\frac{u\,du}{\sqrt{\frac{1}{2\beta^2}u-u^2}};$$

*the differential equation of the cycloid* generated by the circle whose diameter is $\frac{1}{2\beta^2}$.

In this position of the axis, both the angles $u$ and $\psi$ are arcs of great circles described by a point of the axis of figure at a units distance from $O$, and owing to their minuteness may be considered as rectilinear co-ordinates.

If $\alpha$ is not 90°, the sagittae $bc=\frac{1}{2\beta^2}\sin\alpha$; but then, while the angular motion $\psi$ is the same, the arc described by the same point of the axis will be that of a *small circle*, whose actual length will likewise be reduced in the ratio of $1:\sin\alpha$. The curve is therefore a cycloid in all circumstances; and the axis of figure moves as if it were attached to the circumference of a minute circle whose diameter is $\frac{1}{2\beta^2}\sin\alpha$, which rolled along the horizontal circle, $aa'a''$, about the vertical through the point of support.

The centre $e$ of this little circle moves with uniform velocity. The *first term* of the value of $\psi$ (equation 11) is due to this uniform motion: it may be called the *mean precession.*

The second term is due to the circular motion of the axis about this centre, and, combined with the corresponding values of $u$, constitutes what may be called the *nutation*.

These cycloidal undulations are so minute—succeed each other with such rapidity, (with the high degrees of velocity usually given to the gyroscope,) that they are entirely lost to the eye, and the axis seems to maintain an unvarying elevation and move around the vertical with a uniform slow motion.

It is in omitting to take into account these minute undulations that nearly all popular explanations fail. They fail, in the first place, because they substitute, in the place of the real phenomenon, one which is purely imaginary and *inexplicable*, since it is in direct variance with fact and the laws of nature;—and they fail, because these undulations—(great or small, according as the impressed rotation is small or great) furnish the only true clue to an understanding of the subject.

The fact is, that the phenomenon exhibited by the gyroscope which is so striking, and for which explanations are so much sought, is only a *particular and extreme phase* of the motion expressed by equations (6) and (7)—that the self-sustaining power is not *absolute*, but one of degree—that however minute the axial rotation may be, the body never will fall quite to the vertical;—however great, it cannot sustain itself without any depression.

I have exhibited the undulations, as they exist with high velocities,—when they become minute and nearly true cycloids; with low velocities, they would occupy (horizontally) a larger portion of the arc of a semi-circle, and reach downward approximating, more or less nearly, to contact with the vertical: and, *finally*, when the rotary velocity is zero, their cusps are in diametrically opposite points of the horizontal circle, while the curves resolve themselves into vertical circular arcs which coincide with each other, and the vibration of the pendulum is exhibited. All these varieties of motion, of which that of the pendulum is one extreme phase and the gyroscopic another, are embraced in equations (6) and (7) and exhibited by varying $\beta$ from 0 to high values, though, (wanting general integrals to these equations) we cannot determine, except in these extreme cases, the exact elements of the undulations. The minimum value of $\theta$ may however always be determined by equation (8).

If we scrutinize the *meaning* of equations (6) and (7), it will be found that they represent, the first, the horizontal angular component of the velocity of a point at units distance from $O$, and the second, the actual velocity of such point.*

* In more general terms equations (4) express, the first, that the *moment of the quantity of motion* about the fixed vertical axis $Oz$ remains always constant: the *second* that the living forces generated in the body (over and above the *impressed* axial rotation) are exactly what is *due to gravity through the height, h.*

Both are expressions of truths that might have been anticipated; for gravity cannot increase the moment of the quantity of motion about an *axis parallel to*

For $\sin\theta \frac{d\psi}{dt}$ is the horizontal, and $\frac{d\theta}{dt}$ the vertical, component of this velocity. Calling the first $v_h$, and the second $v_v$, and the resultant $v_s$, and calling $\cos\theta - \cos\alpha$, (which is the true height of fall) $h$, those equations may be written

$$v_h = \frac{Cn}{A} \frac{h}{\sin\theta} \qquad (e)$$

$$(v_h{}^2 + v_v{}^2) = v_s{}^2 = \frac{2g}{\lambda} h \qquad (f)$$

This velocity $v_s$ (as a function of the height of fall) is exactly that of *the compound pendulum*, and is *entirely independent of the axial rotation n.* Hence, (as we might reasonably suppose) rotary motion has no power to impair the work of gravity *through a given height*, in generating velocity; but it does have power to *change the direction of that velocity.* Its effect is precisely that of a material undulatory curve, which, deflecting the body's path from vertical descent, finally directs it upward, and causes its velocity to be destroyed by the same forces which generated it.

And it may be remarked, that, were the cycloid we have described *such a material curve*, on which the axis of the gyroscope rested, without friction and *without rotation*, it would travel along this curve by the effect of gravity alone, (the velocity of descent on the downward branch carrying it up the ascending one,) with *exactly the same velocity* that the rotating disk does, through the combined effects of gravity *and* rotation.

Equation (*a*) expresses the horizontal velocity produced by the rotation.

If we substitute its value in the second, we may deduce

$$v_v \text{ or } \frac{d\theta}{dt} = \sqrt{\frac{2g}{\lambda} h - \frac{C^2 n^2}{A^2} \frac{h^2}{\sin^2\theta}}$$

If we take this value at the commencement of descent, *and before any horizontal velocity is acquired*, (making $h$ indefinitely small), the second term under the radical may be neglected, and the first increment of descending velocity becomes $\sqrt{\frac{2g}{\lambda} h}$, precisely what is due to gravity, and *what it would be were there no rotation.*

Hence the popular idea that a rotating body offers any *direct* resistance to a change of its plane, is unfounded. It requires as little exertion of force (in the direction of motion) to move it

*itself;* while its power of generating living force by working through a given height, cannot be impaired.

Had we considered ourselves at liberty to assume them, however, the equations might have been got without the tedious analysis by which we have reached them.

from one plane to another, as if no rotation existed; and (as a corollary) as little expenditure of work.

But deflecting forces are developed, by angular motion given to the axis, and normal to its direction, which are very sensible, and are mistaken for *direct* resistances. If the extremity of the axis of rotation were confined in a vertical circular groove, in which it could move without friction; or if any similar fixed resistance, as a material vertical plane, were opposed to the *deflecting* force, the rotating disk would vibrate in the vertical plane, as if no rotation existed. Its equation of motion would become that of the compound pendulum, $\frac{d\theta}{dt}=\sqrt{\frac{2g}{\lambda}h}$. What then is the resistance to a change of plane of rotation so often alluded to and described? A *misnomer* entirely.

The above may be otherwise established. If in equations (3) we introduce in the second member an indeterminate horizontal force, $g'$, applied to the centre of gravity, parallel to the fixed axis of $y$, and contrary to the direction in which, in our figure, we suppose the angle $\psi$ to increase, the projections of this force on the axes $Ox_1$, $Oy_1$, will be $a'g'$ and $b'g'$ and the last two of these equations will become, (calling cosines $x_1 Oy$ and $y_1 Oy$, $a'$ and $b'$,)

$$A\,dv_y-(C-A)\,n\,v_x\,dt=\gamma M(ag+a'g')\,dt$$
$$A\,dv_x+(C-A)\,n\,v_y\,dt=-\gamma M(bg+b'g')\,dt$$

Multiplying the first by $v_y$ and the second by $v_x$ and adding

$$A(v_y\,dv_y+v_x\,dv_x)=\gamma M[g(a\,v_y-b\,v_x)\,dt+g'(a'\,v_y-b'\,v_x)\,dt].$$

But $(a\,v_y-b\,v_x)\,dt$ has been shown (p. 53) to be $=d.\cos\theta$,—and by a similar process it may be shown that $(a'\,v_y-b'\,v_x)\,dt=$ $=d.(\sin\theta\cos\psi)$. (For values of $a'$ and $b'$, see p. 52.)

Let us suppose now that the force $g'$ is such that the axis of the disk may be always maintained in the plane of its initial position $xz$. The angle $\psi$ would always be 90°, $d\psi=0$, and $d.(\sin\theta\cos\psi)=0$. That is, the co-efficient of the new force $g'$ becomes zero; and the integral of the above equation is as before (p. 54),

$$A(v_y{}^2+v_x{}^2)=2\gamma Mg\cos\theta+h.$$

But the value of $v_y{}^2+v_x{}^2$ likewise reduces (since $\frac{d\psi}{dt}=0$) to $\frac{d\theta^2}{dt^2}$ and the above becomes the equation of the compound pendulum.

$$(g)\qquad \frac{d\theta^2}{dt^2}=\frac{2\gamma Mg}{A}\cos\theta+h=\frac{2g}{\lambda}(\cos\theta-\cos\alpha),\ (h\text{ being determined.})$$

This is the principle just before announced, that, with a force so applied as to prevent any *deflection* from the plane in which gravity tends to cause the axis to vibrate, the motion would be precisely *as if no axial rotation existed.*

To determine the force of $g'$; multiply the first of preceding equations by $b$, and the second by $a$, and add the two, and add likewise $A(v_y db+v_x da)=-Anda\cos\theta$ (see p. 54) and we shall get

$$Ad(bv_y+av_x)+Cnd\cos\theta=\gamma Mg'(a'b-ab')dt.$$

By referring to the values of $a$, $a'$, $b$, $b'$, and performing the operations indicated and making $\cos\psi=o$, $\sin\psi=1$, the above becomes,

$$Ad(bv_y+av_x)+Cnd\cos 0=\gamma Mg'\sin\theta dt.$$

But the value of $(bv_y+av_x)$ (p. 54) becomes zero when $\frac{d\psi}{dt}=o$.

Hence $$g'=\frac{Cnd\cos\theta}{\gamma M\sin\theta dt}=-\frac{Cn}{\gamma M}\frac{d\theta}{dt}\ *$$

The second factor $\frac{d\theta}{dt}$ is the *angular velocity* with which the axis of rotation is moving.

Hence calling $v_s$ that angular velocity, *the value of the deflecting force*, $g'$ may be written (irrespective of signs),

$$g'=\frac{C}{\gamma M}nv_s: \qquad (h)$$

that is, it is directly proportional *to the axial rotation* $n$, and *to the angular velocity* of the axis of that rotation. By putting for $C$, $Mk^2$ (in which $k$ is the distance from the axis at which the mass $M$, if concentrated, would have the moment of inertia, $C$,) the above takes the simple form

$$g'=\frac{k^2}{\gamma}nv_s.$$

In the case we have been considering above, in which $g'$ is supposed to counteract the deflecting force of axial rotation, the angular velocity $v_s$, or $-\frac{d\theta}{dt}$ (equation $g$) is equal to $\sqrt{\frac{2g}{\lambda}(\cos\theta-\cos\alpha)}$.

But in the case of the *free* motion of the gyroscope, this deflecting force combines with gravity to produce the observed movements of the axis of figure.

If, *therefore*, we *disregard* the axial rotation and consider the body simply as fixed at the point $O$, and acted upon, at the center of gravity, by two forces—one of gravity, constant in intensity and direction—the other, the *deflecting* force due to an axial rotation $n$, whose variable intensity is represented by $\frac{C}{\gamma M}nv_s$,

* The effect of gravity is to diminish $\theta$ and the increment $d\theta$ is negative in the case we are considering. Hence the negative sign to the value of $g'$, indicating that the force is in the direction of the *positive* axis of $y$, as it should, since the tendency of the node is to move in the reverse direction.

and whose direction is always normal to the plane of motion of the axis; we ought, introducing these forces, and making the axial rotation $n$ zero, in general equations (3), to be able to deduce therefrom the identical equations (4) which express the motion of the gyroscope.

This I have done; but as it is only a verification of what has previously been said, I omit in the text the introduction of the somewhat difficult analysis.*

Equation (5) becomes (in the case we consider), by integration,

$$\varphi = nt + \psi \cos \alpha$$

which, with the values of $u$ and $\psi$ already obtained, determines completely the position of the body at any instant of time.

Knowing now not only the exact nature of the motion of the gyroscope, but the direction and intensity of the forces which

* To introduce these forces in eq. (3) I observe, first, that as both are applied at $G$ (in the axis $Oz_1$) the moment $L_1$ is still zero and the *first* eq. becomes, as before,

$$Cdv_z = O \text{ or } v_z = \text{const.}$$

And as we disregard the impressed axial rotation, we make this constant (or $v_z$) zero.

The deflecting force $\frac{Cn}{\gamma M} v_s$ (taken with contrary sign to the *counteracting* force just obtained) resolves itself into two components $\frac{Cn}{\gamma M}\frac{d\theta}{dt}$ and $-\frac{Cn}{\gamma M}\frac{d\downarrow}{dt}\sin\theta$, the first in a vertical, the second in a horizontal plane, and both normal to the axis of figure.

The first is opposed to gravity, whose component normal to the axis of figure, is $g \sin \theta$.

Hence we have the two component forces (in the directions above indicated),

$$M.\frac{Cn}{\gamma M}\frac{d\eth}{dt} \text{ and } M\left(g - \frac{Cn}{\gamma M}\frac{d\downarrow}{dt}\right)\sin\theta.$$

These moments with reference to the axes of $y_1$ and $x_1$ will be

$$-\sin\varphi\gamma M\left(g - \frac{Cn}{\gamma M}\frac{d\downarrow}{dt}\right)\sin\theta - \cos\varphi\gamma M\frac{Cn}{\gamma M}\frac{d\eth}{dt}, \text{ and}$$

$$\cos\varphi\gamma M\left(g - \frac{Cn}{\gamma M}\frac{d\downarrow}{dt}\right)\sin\theta - \sin\varphi\gamma M\frac{Cn}{\gamma M}\frac{d\eth}{dt}.$$

Hence equations (3) (making $v_z$ zero, and putting for $M_1$ and $N_1$ the above values, and recollecting the values of $a$ and $b$, (p. 53) become

$$\left.\begin{aligned} Adv_y &= a\gamma Mgdt - aCn\frac{d\downarrow}{dt}dt - Cn\cos\varphi\frac{d\eth}{dt}dt \\ Adv_x &= -b\gamma Mgdt + bCn\frac{d\downarrow}{dt}dt - Cn\sin\varphi\frac{d\eth}{dt}dt \end{aligned}\right\} i$$

Multiplying the equations severally by $v_y$ and $v_x$, adding and reducing (as on p. 53) we get

$$A(v_y dv_y + v_x dv_x) = \gamma Mgd.\cos\theta - Cn\frac{d\downarrow}{dt}d.\cos\theta - Cn\,d\eth\,(v_y\cos\varphi + v_x\sin\varphi)$$

But $v_y \cos\varphi + v_x \sin\varphi$ will be found equal to $\sin\theta\frac{d\downarrow}{dt}$ (by substituting the values

produce it, it is not difficult to understand why such a motion takes place.

Fig. 1 represents the body as supported by a point *within* its mass; but the analysis applies to any position, in the axis of figure, within or without; and figs. 3 and 4 represent the more familiar circumstances under which the phenomenon is exhibited.

Let the revolving body be supposed (fig. 3, vertical projection), for simplicity of projection, an exact *sphere*, supported by a point in the axis prolonged, at $O$, which has an initial elevation $\alpha$ greater than 90°. Fig. 4 represents the projection on the horizontal plane $xy$; the initial position of the axis of figure (being in the plane of $xz$) is projected in $Ox$.

$Ox$, $Oy$, $Oz$, are the three (fixed in space) co-ordinate axes, to which the body's position is referred.

In this position, an initial and high velocity $n$ is supposed to be given about the axis of figure $Oz_1$, so that the visible portions move in the direction of the arrows $b$, $b'$, and the body is left subject to whatever motion about its point of support $O$, gravity may impress upon it. Had it no axial rotation, it would immediately fall and vibrate according to the known laws of the pendulum. Instead of which, while the axis maintains (apparently) its elevation $\alpha$, it moves slowly around the vertical $Oz$, receding from the observer, or from the position $ON''$ towards $ON$.

It is self-evident that the first *tendency* (and as I have likewise proved, the first effect) of gravity is to cause the axis $Oz_1$ to descend vertically, and to generate vertical *angular velocity*. But with this angular velocity, the *deflecting* force proportional to that velocity and normal to its direction, is generated, which pushes aside the descending axis from its vertical path.—But as the direction of motion changes, so does the direction of this force—always preserving its perpendicularity. It finally acquires

of $v_y$ and $v_x$); hence the two last terms destroy each other, and the above equation becomes identical with equation ($a$) from which the 2d eq. (4) is deduced.

Multiplying the 1st equation ($i$) by $\cos\varphi$ and the second by $\sin\varphi$ and adding, we get,

$$A(\cos\varphi dv_y + \sin\varphi dv_x) = -Cnd\theta.$$

By differentiating the values of $v_y$ and $v_x$, performing the multiplications, and substituting for $d\varphi$ its value, $\cos\theta\, d\psi$, (proceeding from the 3d equation (2) when $v_z = 0$) the above becomes

$$A\left(\sin\theta\frac{d^2\psi}{dt^2} + 2\cos\theta\frac{d\psi}{dt}\frac{d\theta}{dt}\right) = -Cn\frac{d\theta}{dt}.$$

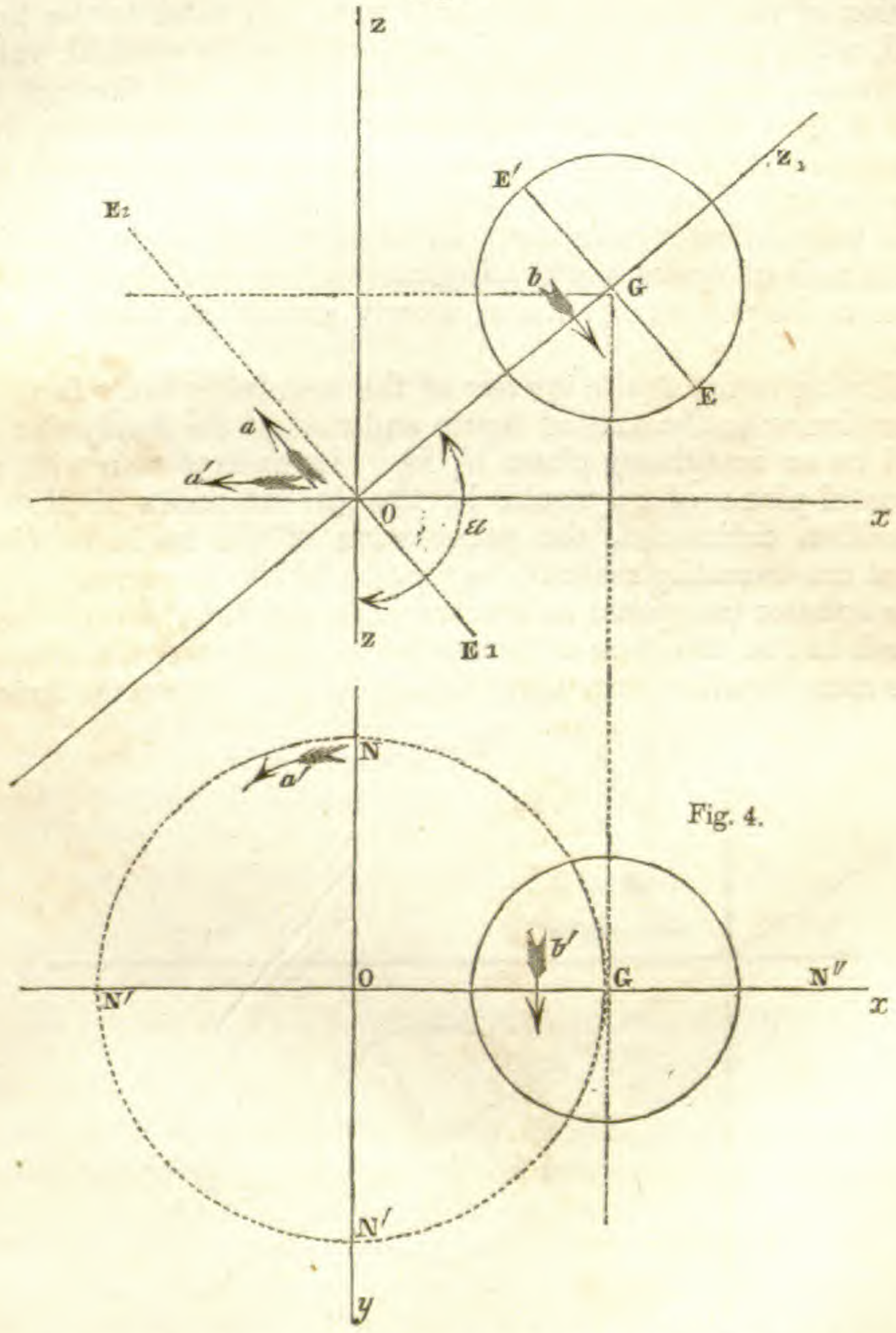
Multiplying both members by $\sin\theta\, dt$, and integrating, the above becomes

$$\sin^2\theta\frac{d\psi}{dt} = \frac{Cn}{A}\cos\theta + l;$$

the same as the 1st equation (4) when the value of the constant $l$ is determined.

an intensity and upward direction adequate to neutralize the downward action of gravity; but the *acquired downward velocity* still exists and the axis *still* descends at the same time acquiring a constantly increasing horizontal component, and with it a still increasing upward deflecting force. At length the descending

Fig. 3.




component of velocity is entirely destroyed—the path of the axis is horizontal; the deflecting force due to it acts directly contrary to gravity, which it exceeds in intensity, and hence causes the axis to commence rising. This is the state of things at the point *b* (fig. 2). The axis has descended the curve *a b*, and

has acquired a velocity due to its *actual* fall $a\,d$; but this velocity has been deflected to *a horizontal direction*. The *ascent* of the branch $b\,a'$ is precisely the converse of its descent. The *acquired* horizontal velocity impels the axis horizontally, while the deflecting force due to it (now at its maximum) causes it to commence ascending. As the curve bends upward, the normal direction of this force opposes itself more and more to the horizontal, while gravity is equally counteracting the vertical, velocity. As the *horizontal* velocity at $b$ was due to a fall through the height $a\,d$, so, through the medium of this deflecting force, it is just capable of restoring the *work* gravity had expended and *lifting* the axis back to its original elevation at $a'$, and the cycloidal undulation is completed, to be again and again repeated, and the axis of figure, performing undulations too rapid and too minute to be perceived, moves slowly around its point of support.

Referring to fig. 3, the *equator* of the revolving body (a plane perpendicular to the axis of figure and *through the fixed point O*,) would be an imaginary plane $E_1\ E_2$. Its intersection with the horizontal plane of $xy$ would be the line of nodes $N$, $N'$. In the position delineated, the progression of the nodes is *direct*. For, at the *ascending* node $N$, any point in the imaginary plane of the equator (supposed to revolve with the body) would move *upwards* in the direction of the arrow $a$, while the node moves in the *same direction from O* (of the arrow $a'$). Were the axis of

Fig. 5.

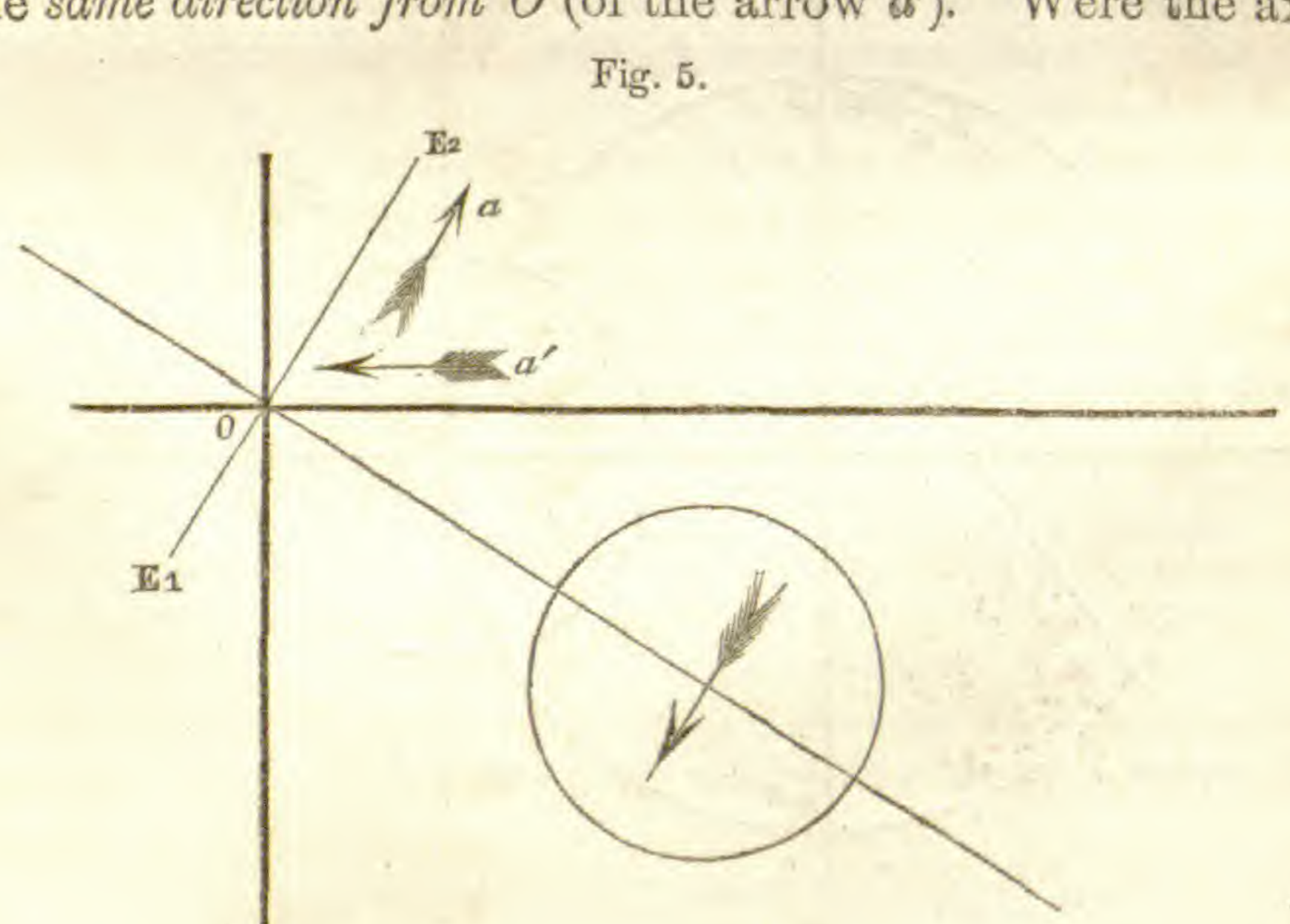
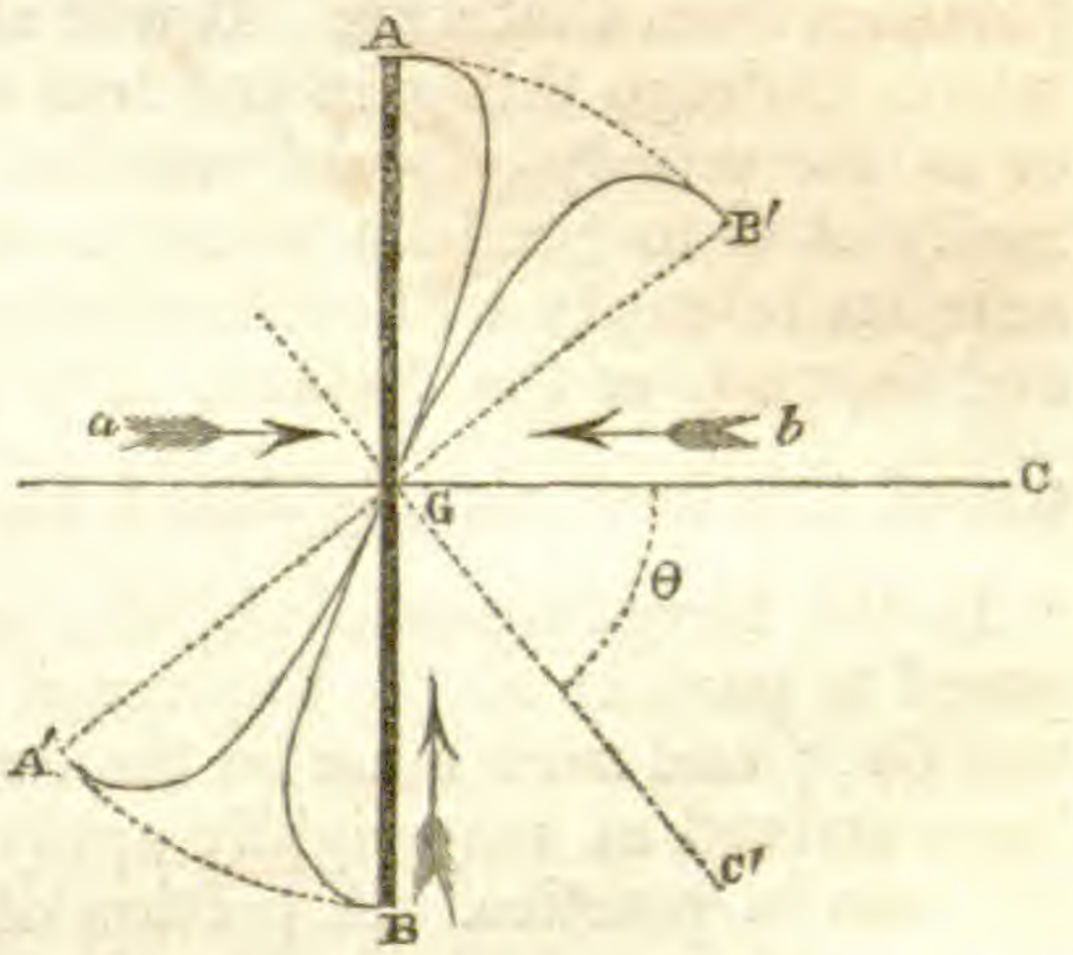



figure below the horizontal plane, (fig. 5) the upward rotation of the point would be from $O$ to $E_2$ (as the arrow $a$), while the progression of the node (in the same direction as before as the arrow $a'$) would be the reverse, and the motion of the node would be *retrograde*—yet in both cases the same in space.

As the deflecting force of rotary motion is the sole agent in diverting the vertical velocity produced by gravity from its downward direction, and in producing these paradoxical effects; and as the foregoing analysis while it has determined its value, has thrown no light upon its origin, it may be well to inquire how this force is created.

Popular explanations have usually turned upon the deflexion of the *vertical* components of rotary velocity by the vertical angular motion of the axis produced by gravity. In point of fact, however, *both* vertical and horizontal components are deflected, one as much as the other; and the simplest way of studying the effects produced, is to trace a vertical projection of the path of a point of the body under these combined motions. For this purpose conceive the mass of the revolving disk concentrated in a single ring of matter of a radius $k$ due to its moment of inertia $C = M k^2$, (see Bartlett Mech. p. 178) and, for simplicity, suppose the angular motion of the axis to take place around the centre figure and of gravity $G$.

Fig. 6.




Let $A\,B$ be such a ring (supposed perpendicular to the plane of projection) revolving about its axis of figure $G\,C$, while the axis turns *in the vertical plane* about the same point $G$. Let the rotation be such that the visible portion of the disk moves upward through the semi-circumference, from $B$ to $A$, while the axis moves downward through the angle $\theta$ to the position $G\,C'$. The point $B$, by its *axial rotation* alone, would be carried to $A$; but the plane of the disk, by simultaneous movement of the axis, is carried to the position $A'\,B'$, and the point $B$ arrives at $B'$ instead of $A$, through the curve projected in $B\,G\,B'$. The equation of the projection, in circular functions, is easily made; but its general character is readily perceived, and it is sufficient to say, that it passes through the point $G$,—that its tangents at $B$ and $B'$ are perpendicular to $A\,B$ and $A'\,B'$,—and that its concavity, throughout its whole length, turned to *the right*. The point $A$ descends on the other, or remote side of the disk, and makes an exactly similar curve $A\,G\,A'$ with its concavity reversed.

The *centrifugal* forces due to the deflections of the vertical motions are normal to the concavities of these curves; hence, on the side of the axis *towards* the eye, they are to the *left*, and on

the opposite or further side, to the *right*, (as the arrows $b$ and $a$.) Hence the joint effect is to press the axis $GC$ from its vertical plane $CGC'$, horizontally and towards the eye. Reverse the direction of axial rotation and the curves $AA'$ and $BB'$ will be the same, except that $AA'$ would be on the *near*, and $BB'$ on the *remote* side of the axis $GC$, and the direction of the resulting pressure will be reversed.

A projection on the horizontal plane would likewise illustrate this deflecting force and show at the same time that there is *no resistance in the plane of motion of the axis*, and that the whole effect of these deflexions of the paths of the different material points, is a mere *interchange of living forces between the different material points of the disk;* but it is believed that the foregoing illustration is sufficient to explain the *origin* of this force, whose measure and direction I have analytically demonstrated.

It may be remarked, however, that the intensity of the force will evidently be directly as the velocities *gained and lost* in the motion of the particles from one side of the axis to the other; or as the *angular velocity of the axis*, and as the distance, $k$, of the particles from that axis. It will also be as the *number of particles* which undergo this gain and loss of living force in a given time; or *as the velocity of axial rotation*. Considered as applied normally at $G$ to produce rotation about *any* fixed point $O$ in the axis, its intensity will evidently be *directly* as the arm of lever $k$, and *inversely* as the distance of $G$ from $O$ ($\gamma$). Hence the measure of this force already found, from analysis, $g' = \frac{k^2}{\gamma} n v_s$.

In the foregoing analysis, the entire ponderable mass is supposed to partake of the impressed rotation about the axis of figure $Oz_1$; and such must be the case, in order that the results we have arrived at may rigidly apply. Such, however, cannot be the case in practice. A portion of the instrument must consist of mountings which do not share in the rotation of the disk. It is believed the analysis will apply to this case by simply including the *whole mass*, in computing the moment of inertia $A$ and the mass $M$, while the moment $C$ represents, as before, that of *the disk alone*.

In this manner it would be easy to calculate what *amount of extraneous* weight (with an *assumed* maximum depression $u$), the instrument would sustain, with a given velocity of rotation.

The analogy between the minute motions of the gyroscope and that grand phenomenon exhibited in the heavens,—the "precession of the equinoxes"—is often remarked. In an ultimate analysis, the phenomena, doubtless, are identical; yet the immediate causes of the latter are so much more complex, that it is difficult to institute any profitable comparison.

At first sight, the undulatory motion attending the precession, known as "nutation" (nodding) would seem identical with the undulations of the gyroscope. But the identity is not easily indicated; for the earth's motion of nutation is mainly governed by the moon, with whose cycles it coincides; and the solar and lunar precessions and nutations are so combined, and affected by causes which do not enter into our problem, that it is vain to attempt any minute identification of the phenomena, without reference to the difficult analysis of celestial mechanics.

On a preceding page, I said that a horizontal motion of the rotating disk around its point of support, without descending undulations, was at variance with the laws of nature. This assertion applied however only to the actual problem in hand, in which no other external force than gravity was considered, and no other initial velocity than that of axial rotation.

Analysis shows, however, that an initial *impulse* may be applied to the rotating disk in such a way that the horizontal motion shall be absolutely without undulation. An initial horizontal angular velocity such as would make its corresponding deflective force equal to the component of gravity, $g \sin \theta$, would cause a horizontal motion *without* undulation.

If the axial rotation $n$, as well as the horizontal rotation, is communicated by an impulsive force, analysis shows that it may be applied in *any plane* intersecting the horizontal plane *in the line of nodes;* but if applied in the plane of the equator (where it can communicate nothing but an *axial* rotation $n$), or in the horizontal plane, its intensity must be infinite.

My announced object does not carry me further into the consideration of the gyroscope than the solution of this peculiar phenomenon, which depends solely upon, and is so illustrative of, the laws of rotary motion.

If I have been at all successful in making this so often explained subject more intelligible—in giving clearer views of some of the supposed effects of rotation, it has been because I have trusted solely to the *only* safe guide in the complicated phenomena of nature, *analysis*.

ART. VII.—*Observations upon the Cretaceous Strata of the United States with reference to the Relative Position of Fossils collected by the Boundary Commission*;* by JAMES HALL.

THE list of fossil species from localities visited by the Mexican boundary commission shows so large a number identical with those described and figured by Dr. Roëmer in his *Kreidebildungen von Texas*, that we cannot doubt the occurrence of the same beds throughout the whole extent surveyed, as far as the neighborhood of El Paso and Frontera.

These collections made at intervals over so wide an extent would be likely to give us some representative species from different and successive beds of the formation, should it there exhibit similar subdivivisions as are elsewhere known in this system, in other parts of the country. With the exception of two species, they are all distinct from those known in the cretaceous formation of New Jersey and Alabama, where the fossils have been most carefully studied. They are equally distinct likewise, from the species occurring in Nebraska; while those from the last named region present so many species in common with New Jersey and Alabama, that we cannot doubt the general equivalency of the beds in these distant localities. The species known from Tennessee, are likewise identical with New Jersey species to a great extent; leaving no doubt as to the exact equivalency of the formation in the two localities.

The cretaceous formation as known in New Jersey, can therefore be traced by the Atlantic coast, to Alabama, and thence into Tennessee, and even southern Illinois; and though not yet followed continuously to the northward, it is nevertheless recognized in Nebraska by numerous identical species of fossils.

When we carry forward our investigations in a southwesterly direction however, we soon lose to a great extent the evidence of identity in the fossils; and in Arkansas the *Exogyra costata*, *Ostrea versicularis*, and *Trigonia thoracica*, are almost the only species identical with those known on the east of the Mississippi river. At the same time other species occur in considerable abundance, which are of decidedly cretaceous character, leaving no doubt of the existence of that formation: though we have lost the evidences which guide us in more eastern localities.

Since this change in the character of the fossils is quite observable as far north as Fort Washita in Arkansas; and since the types of the greensand of New Jersey and Alabama extend as far north as Tennessee and Illinois, it is clear that the change

* From the Report of the United States and Mexican Boundary Survey, under the orders of W. H. Emory, 1st Cavalry, United States Commissioner, etc.

is not due to climatic influence or to geographical distance. It would moreover be unreasonable to suppose that such a change in the nature of the sediment had taken place as to destroy within this short distance all the forms of life so well known farther east, and to replace them with others adapted to the different condition. Indeed we are not informed that there is any great change in the lithological character of the strata; though it is true that the cretaceous beds of Arkansas, Texas, and New Mexico (as we judge from the specimens), are more calcareous than those of New Jersey and Nebraska. But they are not more so than in Alabama, where the "Rotten limestone" attains a thickness of 400 feet and contains species common to the regions just mentioned.

Therefore it is not due either to difference of latitude or to change of conditions in the sediment, that we have this difference in the organic remains of the formation; but it is doubtless true that this region of the cretaceous formation of the southwest which has yielded nearly all the fossils, represents a *different epoch* in the *cretaceous period*, from those beds farther east, and in the northwest, of which the organic contents are better known.

The relations of that part of the cretaceous formation, which is developed in Texas and New Mexico, to the same formation as known on the east of the Mississippi river, and in Nebraska, becomes a matter of much interest and importance.

The various examinations in Texas and in Arkansas, as well as along several lines of survey, do not give us any sections of these beds showing their relations with other formations; or indications that there may be more than a single member of the cretaceous formation from which all these fossils have been derived. Before attempting to theorize in regard to the probable cause of this difference in the fossils of the cretaceous strata at these distant points, we may bring together in a general manner the results of investigations made at various points and at different times, which may serve to throw some light upon this question.

In the earlier investigations of the cretaceous formations of New Jersey and other parts of the United States, Dr. Morton subdivided the whole into three groups or divisions.

FIRST GROUP.—Upper Cretaceous Strata.

SECOND GROUP.—Medial Cretaceous Strata.

THIRD GROUP.—Lower Cretaceous Strata.

The upper division embraced the Nummulitic limestone of Alabama; being especially characterized by the presence of *Pla-*

*giostoma dumosum* and *Nummulites Mantelli* (*Orbitoides Mantelli*). This rock is now regarded as belonging to the older tertiary formations.

The medial division was regarded as contemporaneous with the white chalk of Europe.

The lower division embraced the "ferruginous sand deposits of the Atlantic states, extending from Martha's Vineyard to South Carolina and Alabama and into Mississippi, Arkansas and Missouri."

These strata were at that time regarded as contemporaneous with those which lie between the white chalk and Oolite in Europe.

The foregoing subdivisions were proposed by Dr. Morton in some "additional observations" appended to his "Synopsis of the Organic Remains of the Cretaceous group of the United States," and published in the Journal of the Academy of Natural Sciences in 1842. Accompanying this classification of the cretaceous formation is a list of fossils from each of the subdivisions, including all those which had been described up to that period.

Prof. Rogers, in his Report upon the Geology of New Jersey in 1840, proposed a division of the cretaceous formation of the state into five members. These subdivisions, however useful they may have been topographically, are not accompanied by the palæontological evidence necessary to enable us to determine their value as distinctive groups, or to aid us in a comparison with the sequence in other localities.

More recently the investigations made during the geological survey of the state of New Jersey, have thrown further light upon the order of succession, and the lithological character of the members composing the greensand formation of New Jersey. The section given by Prof. Cook, which has been verified by borings in several places, leaves no doubt that we have now arrived at a knowledge of the true relations of the different members of this period as developed in New Jersey; and it is the more interesting since it enables us to show the true position of certain well marked and widely distributed cretaceous fossils, in relation to others which approximate in character to tertiary types.

The following section gives the expression of all that is at present known regarding the order of succession among the members of the system as they occur in southeastern New Jersey.*

* This section has been communicated to me by Prof. Geo. H. Cook, of the New Jersey Geological Survey, who gives some additional information beyond that already published in his Geological Report.

SECTION OF THE SUCCESSIVE BEDS COMPRISING THE CRETACEOUS FORMATION OF NEW JERSEY.

8. GREEN SAND, 3d OR UPPER BED.

This bed admits of a triple division, the central portion is nearly destitute of fossils, while those of the upper and lower divisions are mostly dissimilar.

7. QUARTZOSE SAND RESEMBLING BEACH SAND.

This bed is (so far as known) quite destitute of fossils.

6. GREEN SAND, 2D BED.

(*a*) Yellow limestone of Timber Creek.
Characterized by *Eschara digitata*, *Montivaltia* (*Anthophyllum*) *atlanticum*, *Nucleolites crucifer*, *Anachytes cinctus*, *A. fimbriatus*, Morton.

(*b*) A bed of nearly unchanged shells.
Among the characteristic fossils of this bed are *Gryphæa vomer*, *G. convexa*, and *Terebratula Harlani*.

(*c*) Green sand, etc.
*Cucullea vulgaris* is the most characteristic fossil of the lower division.

Equivalent to Nos. 4 and 5 of the Nebraska Section.

5. QUARTZOSE SAND HIGHLY FERRUGINOUS THROUGHOUT, AND ARGILLACEOUS IN ITS UPPER PARTS.

This rock is sometimes indurated or cemented by oxyd of iron.
*Exogyra costata*, *Ostrea larva*, *Belemnitella mucronata*, *Pecten* (Neitha) *quinque-costatus;* and many other fossils mostly in the condition of casts of the interior, or impressions of the exterior.

4. GREEN SAND, 1ST OR LOWER BED.

Several subdivisions may be recognized depending on the character of the marl, etc.
*Exogyra costata*, *Ostrea larva*, *Belemnitella mucronata*, *Terebratula Sayi*, (*Gryphæa convexa* and *G. mutabilis*), *Ostrea vesicularis*.

3. DARK COLORED CLAY CONTAINING GREEN SAND IN IRREGULAR STRIPES AND SPOTS.

*Ammonites Delawarensis*, *Ammonites placenta*, *A. Conradi*, *Baculites ovatus*, casts of *Cardium*.

2. DARK COLORED CLAY.

[Position of beds Nos. 2 and 3 of the Nebraska Section.—At the present time the evidence tends to show that No. 1, of the Nebraska section is represented by Nos. 1 and 2, and that Nos. 2 and 3 of the Nebraska section are wanting, and would find a place between Nos. 2 and 3 of this section if existing.]
This bed contains large quantities of fossil wood; (no animal remains are known to occur in it).

1. FIRE CLAY AND POTTER'S CLAY.

This bed contains fossil wood, and numerous impressions of leaves; but no animal remains.

GNEISS.

---

In Alabama, according to the report of Prof. Tuomey, the cretaceous strata admit of a threefold division; the upper members consisting of the "rotten limestone," a central arenaceous group, and a lower dark colored clay.

Without at present having the means of exact comparison, it may be inferred that there is a close agreement between the different members of the series in Alabama and New Jersey. The specific identity of many of the characteristic fossils, leaves no

doubt as to the close similarity of the formation there developed, with the beds in New Jersey from which a large part of the fossils described by Dr. Morton were obtained. The calcareous part of the formation in Alabama acquires a far greater development than in New Jersey, and appears to be there the principal repository of the fossils of this period.

It is now more than fifty years since Messrs. Lewis and Clarke, in their expedition to the Columbia River, brought from the Great Bend of the Missouri River some fossils which were afterwards identified by Dr. Morton as belonging to the cretaceous formation; and to beds of the same age as the marl or ferruginous sand of New Jersey, Delaware and Alabama. Subsequently Mr. Nuttall brought some species from the same locality. Dr. Morton in his Synopsis (1834) acknowledges the receipt of *Gryphæa Pitcheri*, and other cretaceous fossils of great interest from the plains of Kiamesha in Arkansas, from Dr. Z. Pitcher of the United States Army. Dr. Morton also mentions other fossils from the falls of Verdigris river in the same territory.

It is nearly twenty years since Mr. Nicollet first visited and explored the country about the sources of the Mississippi and some parts of the Missouri river, as far up as Fort Pierre. The collections made by this gentleman enabled Dr. Morton to designate about sixteen species of cretaceous fossils, half of which were regarded as common to that region, New Jersey and Alabama.

Mr. Nicollet in his report has given the following section of the beds of the cretaceous formation upon the upper Missouri.

D. "A plastic clay deposit, about 200 feet thick, divided into two equal parts by a stratum of carbonate of lime in nodules.

C. "A ferruginous clay, of a yellowish color, containing masses resembling septaria and seams of selenite."

B. "A calcareous marl, generally from 30 to 40 feet thick."

A. "Argillaceous limestone, containing *Inoceramus Barabini* [?] in great numbers and very much compressed, and so arranged as to give the rock a slaty appearance" (at Dixon's Bluff).*

The importance of these divisions does not appear to have been fully appreciated, or the collection of fossils was not sufficient to establish the restriction of species within the limits thus indicated.

In the mean time the explorations of Lieut. Fremont, of Lieut. Abert, of Capt. Stansbury and others, and more extended examinations made under the direction of Dr. D. D. Owen, in his geological survey of the Chippewa Land District have brought to light other cretaceous species from this region;† while the

* The species of Inoceramus in Mr. Nicollet's collection, in a condition here described, was subsequently identified by me as the same with that brought by Capt. Fremont from the Smoky Hill River. (See Report, p. 310.)

† In his report Dr. Owen does not notice the subdivisions of Mr. Nicollet's section; and the cretaceous species figured and described appear all to have been derived from a single bed of the formation.

several Pacific Railroad surveys have shown the occurrence of cretaceous fossils at various points farther to the south, and at intervals which indicate a continuation of the formation from the Missouri river to New Mexico. More recently Dr. Evans, who had previously visited this region as assistant in the geological survey of Dr. Owen, has collected, and, with Dr. B. F. Shumard, has described several new cretaceous species from the same region.

In 1853, Messrs. F. B. Meek and F. V. Hayden made an extensive collection of the fossils of the cretaceous formation upon the Missouri river in Nebraska; and among these somewhat more than thirty new species, a number equal to all the cretaceous species before known as occurring in that region. These species were described by the writer in connexion with Mr. Meek, in the Memoirs of the American Academy of Arts and Sciences.* A section of the cretaceous and tertiary strata of the Missouri river and the Mauvaises Terres, compiled from the notes of Mr. Meek, made upon the ground, and verified by subsequent examination of the fossils, likewise accompanied the paper just noticed, on page 405 of the same volume.

The order of succession among the beds constituting the cretaceous formation and their lithological character there established are as follows:

SECTION OF THE MEMBERS OF THE CRETACEOUS FORMATION, AS OBSERVED ON THE MISSOURI RIVER BELOW FORT PIERRE, AND THENCE WESTWARD, INCLUDING THE TERTIARY BEDS OF THE MAUVAISES TERRES.

III. TERTIARY.

Indurated clays, beds of sandstone, conglomerate, limestone, etc., containing remains of Mammalia, and Chelonia, with a few species of fresh water shells.

II. CRETACEOUS FORMATION OF NEBRASKA.

| | | |
|---|---|---|
| Equiv. of Nos. 3, 4, 5 and 6 of New Jersey section. | Nicollet's C and D. | 5. Arenaceous clay passing into argillo-calcareous sandstone, 80 feet thick. |
| | | 4. Plastic clay with calcareous concretions, containing numerous fossils, 250 to 300 feet thick. (This is the principal fossiliferous bed of the cretaceous formation upon the upper Missouri.) |
| | Nicollet's A and B. | 3. Calcareous marl, containing *Ostrea congesta*, *Inoceramus problematicus*,† scales of fishes, &c., 100 to 150 feet thick. |
| | | 2. Clay containing few fossils. |
| | | 1. Sandstone and clay, 90 feet. The probable equivalent of Nos. 1 and 2, of the New Jersey section. |

I. CARBONIFEROUS FORMATION.

The sandstone No. 1, of section rests upon buff-colored magnesian limestone of the upper Carboniferous period.

* Descriptions of new species of Fossils from the Cretaceous formation of Nebraska, by James Hall and F. B. Meek. Memoirs of the American Academy of Arts and Sciences, vol. v, new series.

† In a subsequent exploration of this region, Dr. Hayden discovered *Inoceramus problematicus* in this bed, corresponding in all respects with those collected by Mr. Nicollet, and in precisely the same conditions and in a rock identical with that

In this section, Nos. 2 and 3 correspond to A and B of Mr. Nicollet's section; while the sandstone No. 1 was either overlooked by him or may have been referred to the Carboniferous strata.*

The division C and D, Mr. Nicollet's section, are subdivisions of Nos. 4 and 5, of our section, or probably of No. 4 alone, since No. 5 is not known to occur on that part of the Missouri which was examined by Mr. Nicollet. Although admitting of several subdivisions from changes in lithological character, the beds of No. 4 do not present any groups of fossil species restricted within the physical or lithological limits designated, and they can therefore scarcely be regarded as of importance in the classification of the formation, or valuable in tracing the limits of its members over a wide extent of country.

The subdivisions A and B corresponding to Nos. 2 and 3 of our section, are more important; and although yielding so few fossils on the Missouri they become well marked in other parts of the country. The "*Inoceramus Barabini*" represented by Mr. Nicollet as found in great numbers at Dixon's Bluff, "very much compressed and so arranged as to give the rock a slaty structure," is undoubtedly the *Inoceramus problematicus* which is known to occur in this position and does not occur in the higher beds of the formation upon the Missouri, so far as known at the present time. The *Ostrea congesta*, and all the other fossils from beds Nos. 2 and 3, of the section, are unlike species from New Jersey or Alabama, and appear to be restricted to these beds. At the same time the species identical with, or analogous to species of New Jersey and Alabama occur in beds Nos. 4 and 5, which may be regarded as subdivisions of one group.

We are warranted therefore in referring the beds above No. 3, to the age of the fossiliferous beds of New Jersey and Ala-

in which the specimens occur brought by Capt. Fremont from the Smoky Hill river, and by Capt. Stansbury from between the Big and Little Blue rivers.

Dr. Hayden has likewise made extensive collections in other parts of the Nebraska Cretaceous and Tertiary formations during the past two years. The new species of these collections have been described by Messrs. Meek and Hayden in several papers published in the Proceedings of the Academy of Natural Sciences of Philadelphia. These explorations, with the extensive collections of fossils, have served to sustain the correctness of the order of succession among the subordinate members of the series, as given in the section above, indicating however that the beds Nos. 2 and 3, as well as Nos. 4 and 5, may in some localities merge into each other; while the limits between Nos. 3 and 4 remain well marked throughout the region explored.

A careful comparison of *Inoceramus fragilis*, from bed No. 2, Nebraska Section (Hall and Meek, Memoirs Amer. Acad., vol. v, new series, page 388) has satisfied both Mr. Meek and myself, that it is identical with *I. problematicus*, the specimen described being the young of that species. The young specimens of the latter shell from Arkansas and Smoky Hill river present no essential differences from those of Nebraska.

* From the fact that Mr. Nicollet remarks (page 35) that the part of stratum A, above water on the day of his "examination was three feet," we may infer that the sandstone No. 1, was not seen by him.

bama, while we have yet no evidence that Nos. 2 and 3 do occur in either of these States.

The beds Nos. 3, 4, 5 and 6, of the New Jersey section, given on a preceding page, correspond in their fossils with Nos. 4 and 5, of the Nebraska section; leaving the 3d greensand of New Jersey (No. 8 of that section) unrepresented in the northwest, so far as known at the present time.

The New Jersey beds Nos. 1 and 2, which are marked only by fossil wood and impressions of leaves, appear to be represented by No. 1 of the Nebraska section, judging from the general character of the remains yet known in the two. Should this inference prove to be correct, the beds Nos. 2, and 3, of the Nebraska section, will hold a position between Nos. 2 and 3 of the New Jersey section; but I do not regard this question as yet determined.

The relations of the beds Nos. 2 and 3 of the Nebraska section, and their characteristic fossils, become very important when we undertake the comparison of the cretaceous formation of Texas and New Mexico, with those of Nebraska, Alabama and New Jersey.

The persistence and wide distribution of *Inoceramus problematicus*, and its restriction to beds Nos. 2 and 3, and their equivalents so far as at present known, render it of great value in determining a geological horizon. This species was brought from the Missouri River by Mr. Nicollet.* It was collected by Capt. now Col. Fremont,† upon the Smoky Hill Fork; where it occurs in a gray or buff-colored, and also in a blue, slaty limestone, in great numbers; and being extremely flattened, gives to the rock a slaty structure, as described by Mr. Nicollet.

The specimens collected by Lt. Abert‡ at Poblazon, are doubtless of this species; and are referred to by Prof. Bailey to the same species as those of Fremont's Report. The same species was brought by Capt. Stansbury§ from between the Big and

* Report on the Upper Mississippi River, by J. N. Nicollet, 1843.

† Report of the Exploring Expedition to the Rocky Mountains, by Capt. J. C. Fremont, 1845. Appendix Geological Formations and Organic Remains, by James Hall. At the time of my examination of Capt. Fremont's collection, I had an opportunity of comparing the specimens of Inoceramus with those brought from the Missouri by Mr. Nicollet, and identified the specimens in the two collections as the same species. The collections of Mr. Nicollet were at that time broken up, and I saw some of them in Prof. Ducatell's possession in Baltimore, and others in Georgetown. The information given me was, that they were from near the Great Bend of the Missouri; but from the examination of Mr. Nicollet's Report, it is very clear, from his statements, p. 35, that this Inoceramus occurs at Dixon's Bluff and not at Great Bend, since Mr. Nicollet refers to the former locality as exhibiting the base of the formation.

‡ Report on a Geographical Examination of New Mexico, by Lieut. J. W. Albert, 1848. Notes concerning the minerals and fossils by Prof. J. W. Bailey, page 547.

§ Exploration of the Valley of the Great Salt Lake by Capt. Howard Stansbury, 1852. Appendix Geology and Palæontology, by James Hall; page 402.

Little Blue Rivers, in precisely the same conditions and in a similar rock. In 1854 I received specimens of the same fossil collected at several points in Arkansas by Col. Fremont in his later expedition: these occur in part in a bluish or dull ash-colored argillaceous limestone, and others in a gray or buff-colored limestone.

Dr. Schiell collected this species of Inoceramus at the bend of the Arkansas River; and it is mentioned by Dr. Roëmer as occurring near New Braunfels in Texas. Dr. F. V. Hayden has more recently brought the same from the bed No. 3, Nebraska, as just stated on a previous page.

In Arkansas this fossil is collected from the same localities and apparently in the same position from which are obtained numerous species of Echinoderms, *Gryphæa Pitcheri*, and other fossils, of species yet unknown in Nebraska, or in any localities east of the Mississippi River.

Fragments of the same species of Inoceramus occur in an argillaceous limestone, among the collections of the Boundary Survey, from the Basin of the Rio Grande. In the same connexion occur several Echinoderms of species identical with those from Arkansas, *Gryphæa Pitcheri*, *Ammonites Texanus*, etc.

The collections of the Pacific Railroad Surveys, which have been placed in my hands for examination, show that *Ostrea congesta* was collected by Mr. Marcou from a point three miles north of Galisteo; between Fort Smith and Santa Fe.* This fossil in Nebraska is associated with *Inoceramus problematicus*. In the same collection and from the same locality, near Galisteo, there were specimens of a slaty limestone containing fragments of Inoceramus, which, although not identified at the time, is probably the *Inoceramus problematicus*. Thus we have abundant evidence of the distribution of this species from Nebraska to New Mexico.

The section already established for the cretaceous strata upon the Missouri as given above, and the subsequent discovery by Dr. Hayden of the occurrence of *Inoceramus problematicus* in the beds Nos. 2 and 3 of that section, serve to fix the place of that fossil in the series in reference to the other beds of the section.

From the analogy of the beds Nos. 4 and 5, and the identity of several important species of fossils, with those of New Jersey, Alabama and Tennessee, we may regard the position of this fossil as determined in reference to the members of the series which occur in these States; this species never having been found, so far as we are aware in either New Jersey, Alabama or Tennessee. This fossil thus becomes one of the best guides for the identification of certain strata in the cretaceous system of the United States.

* See Pacific Railroad Reports, Survey of the 32nd parallel, Chapter IX.

In a paper recently published in the Proceedings of the Academy of Natural Sciences by Messrs. Meek and Hayden, speaking of the geographical distribution of the cretaceous fossils, they refer to the well known species, *Ammonites placenta*, *Scaphites Conradi*, *Baculites ovatus*, and *Nautilus Dekayi*, as being common to the central or upper portions of the New Jersey cretaceous strata, to the "Rotten limestone" of Alabama, and to beds Nos. 4 and 5 of Nebraska. Alluding to the position of the cretaceous beds of the southwest, they remark:—

"At the same time, the total absence of the above named fossils, and indeed so far as we yet know, of all the other species of the lowest and upper two Nebraska cretaceous formations, in the rocks from which Roëmer and others collected so many species in Texas, and other southern localities, renders it highly probable that if the latter occur at all in Nebraska, they must be represented by the beds Nos. 2 and 3 of our section. This conclusion is further strengthened by the fact, that the only Nebraska species yet found in the southwest, so far as we know, are *Inoceramus problematicus* and *Ostrea congesta*, both of which are unknown in the northwest, excepting in the above named beds, and are mainly restricted to the latter. The well marked specific characters of these two fossils, and their limited vertical range, together with their extensive geographical distribution, renders the bed in which they occur a horizon of the highest importance in the identification of strata at remotely separated localities in these far western territories.

"That these beds or formations of the same age, are widely distributed over a vast area of country, extending from near the Great Bend of the Missouri in lat. 44° 15′, long. 99° 20′, westward to, and perhaps beyond, the eastern slope of the Rocky Mountains, and far south into Texas and New Mexico, is highly probable, from the occurrence of these characteristic fossils at many widely separated localities in this region. At any rate, we know, from information obtained through Mr. Henry Pratten, of the Geological Survey of Illinois, that *Inoceramus problematicus* is found in a light-colored limestone overlying a red sandstone on Little Blue River, a tributary of Kansas River. Col. Fremont also collected specimens of the same shell from a similar rock on Smoky Hill River, in lat. 39°, lon. 98°, and at other localities between there and the Rocky Mountains.* More recently Lieut. Abert found the same, or a closely allied species, at a point as far southwest as lat. 35° 13′ N., long. 107° 2′ W., and apparently on the western declivity of the anticlinal axis of the Rocky Mountains†. Roëmer likewise collected in Texas specimens of a shell he refers to *Inoceramus mytiloides* of Mantell,

* See Prof. Hall's Figures and Remarks in Fremont's Report, p. 174, Pl. 4.
† Lieut. Abert's Report of Explorations in New Mexico and California, p. 547.

which is considered identical with *I. problematicus* of Schlotheim. In addition to this, we have seen, in Mr. Marcou's collection, specimens of *Ostrea congesta* from Galisteo, between Fort Smith and Santa Fe, where it probably holds the same geological position as the so called *Gryphaea dilatata.*

"The formations from which the above named fossils were obtained in the southwestern territories, appear, from the statements of the various explorers of that region, to repose on a series of red, yellow, and whitish sandstones, and various colored clays, which are referred by Mr. Marcou to the Jurassic and Triassic systems. These lower beds we think are represented wholly or in part in Nebraska, by our formation No. 1, which, as previously stated, we regard as probably belonging to the lower part of the cretaceous system, though it may be older."

Finally in reference to the relative position in the series of a large part of the cretaceous fossils of the Boundary Survey, I have already in a previous communication stated, that I regard them as occurring in the same geological horizon with the beds of Smoky Hill River, Poblazon etc. I am now prepared to fix their position in the same parallel with beds Nos. 2 and 3 of the Nebraska section, and below those beds in New Jersey and Alabama which contain *Baculites ovatus, Nautilus DeKayi* and *Ammonites placenta.*

The reasons for this conclusion are obvious from what has preceded. The most conspicuous known fossils of beds 2 and 3 in Nebraska, are found in Arkansas and elsewhere associated with many of the species of the Boundary Survey Collections, and from the persistence of *Inoceramus problematicus*, and the almost uniform character of the rock in which it occurs from Nebraska to New Mexico, we can have no doubt that the beds containing this fossil everywhere occupy the same horizon.

The collections from the southwest have never furnished specimens of the cephalopods enumerated above, which characterize the upper cretaceous strata, and the few fossils which are common to Texas and New Mexico and New Jersey, render it probable that the higher beds of the formation have thinned out in that direction to a degree which renders them subordinate in importance to the lower beds of the system. The few specimens identical with species known in New Jersey, Alabama and Tennessee, appear, from their color and the character of the associated rock, to have been obtained in a different bed from that of the greater number of specimens in the collection, which are associated with a more calcareous rock. At the same time, the absence of sections of strata leaves us without positive information in this respect.*

* A single observation in the notes accompanying the specimens leads me to infer that *Exogyra costata*, and one or two species besides, were collected from a higher position in the cliff, than the other fossils. Since however it is probable that many

In the present state of our knowledge, it would appear, that the beds 2 and 3 of the cretaceous formation of Nebraska have gradually increased in thickness and importance in a southwesterly direction, and at the same time have become more fossiliferous. In tracing the same beds through Arkansas, we find in addition to *Inoceramus problematicus*, either in beds somewhat higher in the series or associated with that fossil, *Holectypus planatus*, *Toxaster elegans*, *Holaster simplex*, *Cardium multistriatum*, *Inoceramus confertim-annulatus*, *Gryphæa Pitcheri*, and others which occur also among the Boundary collections. These facts clearly show that the beds have become much more fossiliferous than on the Missouri, or on the Kansas and Blue Rivers; and we must regard the greater part of the Boundary collections as derived from the horizon of these beds.

From the great vertical range of the characteristic cephalopods above enumerated in New Jersey, and their wide geographical distribution, and from their marked distinction to the types of fossils holding the lower position, we shall probably find it convenient to subdivide the cretaceous formation into three great groups.

3. The upper division, comprising the first and second marl beds of New Jersey, with the intermediate ferruginous sand, and the clay below the first greensand bed; parallel to the beds 4 and 5 of Nebraska.

2. The middle division, equivalent to the beds 2 and 3 of Nebraska, the calcareous and higher argillaceous beds of the southwest, Arkansas, Texas, and New Mexico, containing many *Echinoderms*, *Inoceramus problematicus*, *Gryphæa Pitcheri*, *Hippurites*, *Caprina*, *Nerinea*, *Ammonites Texanus*, and numerous other fossils.

1. The lower division, represented by No. 1 of the Nebraska section, and including the various sandstones and shales or clays at the base of the formation in the Llano Estacado, and other portions of New Mexico; and probably equivalent to the lower clay beds of New Jersey, in which the only fossils yet known are of vegetable origin.

It is not unlikely that the medial division may prove in many localities to be divisible into distinct beds beyond those recognized in Nebraska; or, that as the formation expands to the southward, other beds not known on the Missouri will come in, or that the two there known will be found to become much modified in character.

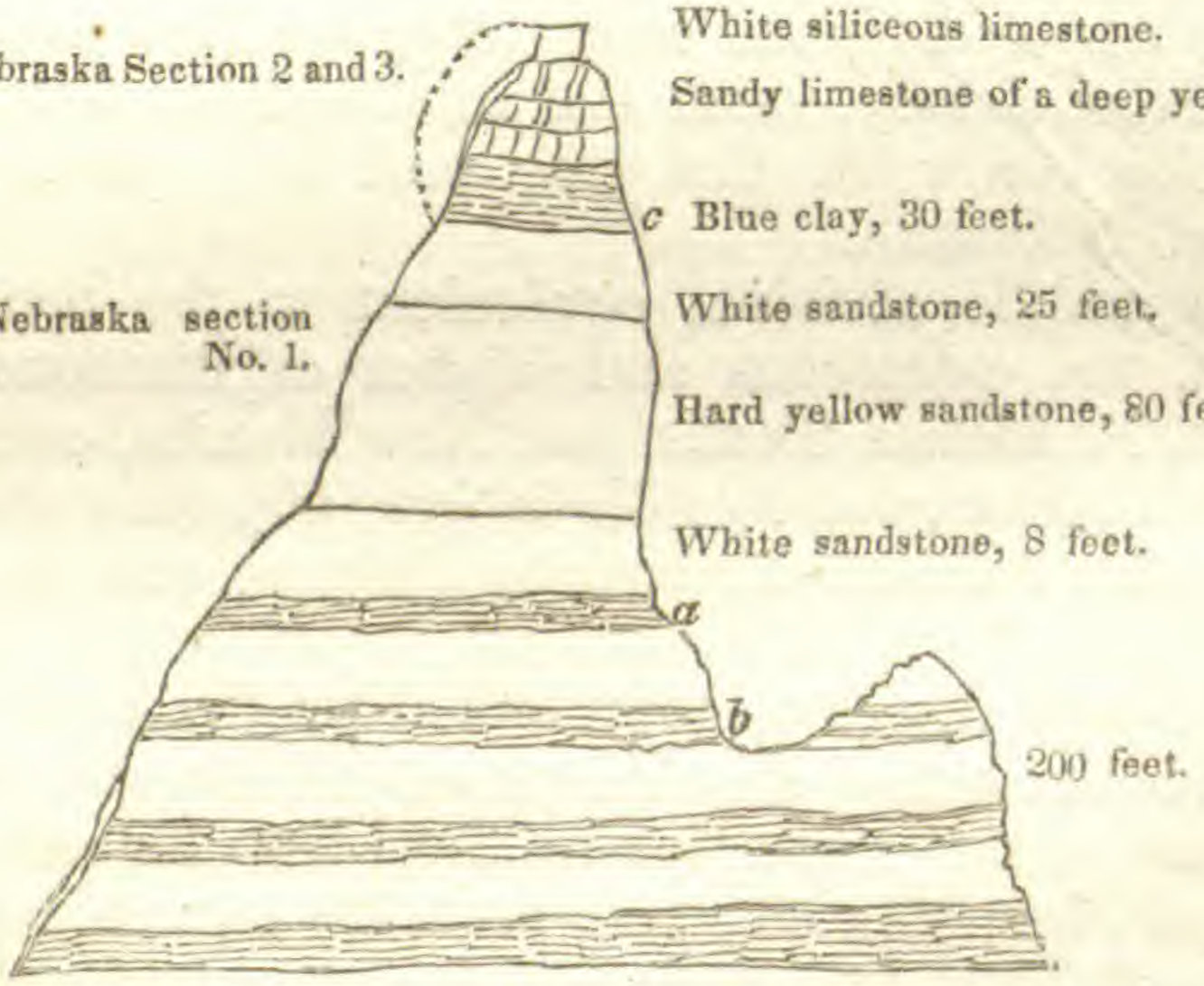
species, not known in the same association in New Jersey and Alabama, may occur in connexion with *Exogyra costata* in the southwest, we cannot at this time separate the species belonging to the upper and lower divisions of the formation.

I learn also from Dr. Parry, since these pages were written, that he regards the bed containing *Exogyra costata* and other species, as holding a higher position than the calcareous beds of Leon Springs, and other localities along the route.

From the facts before us, it appears, that Nos. 4 and 5 of the Upper Division, which are so largely developed on the upper Missouri, become gradually attenuated towards the south and southwest, and lose in a great measure their distinctive fossils.

The observations made in the course of the Boundary Survey, and in all the other surveys in the southwest, show the occurrence of various colored sandstones and clays below the fossiliferous beds identified, as above, with Nos. 2 and 3 of the Nebraska section. Indeed we have evidence, from numerous observations, of the occurrence of a similar sandstone at so many points from Missouri to New Mexico, as to render it certain that the formation is continuous over this wide extent of country.

The observations of Mr. Marcou, on the line traversed by one of the Pacific Railroad Surveys, induced him to regard these sandstones as of older date than the cretaceous formation. In a section (here copied) given by him (Bulletin Soc. Geol. de France, tome xii, p. 878,) he recognizes a series of sandstones and clays beneath limestones which are of unquestionable cretaceous age.




"*a*. Bed of variegated marls in contact with the jurassic formation."
"*b*. Alternations of calcareo-argillaceous marls of variegated colors. (Red, green and white)."
"*c*. Bed of *Gryphæa dilitata* and of *Ostrea Marshii*."*

Having examined the specimens in Mr. Marcou's collection from this locality, I have no hesitation in saying that the specimens labelled by him *Gryphæa Tucumcarii*, (=*G. dilatata*, var. *Tucumcarii*, Bull. Soc. Geol. de France, tome xii, pl. 21) are the *Gryphæa Pitcheri* of Morton, and present no features either in

* These explanations of the section quoted above are those given by Mr. Marcou. The designations at the right hand are those given by him in the text accompanying the section.

form, character, condition of preservation, or otherwise, which can serve to distinguish them from *Gryphæa Pitcheri* in the Boundary Survey collections, from strata forming a continuation of the Llano Estacado.*

In the section of Pyramid Mountain given by Mr. Marcou, the exhibition of the sandstones and clays, beneath the limestone with *Gryphæa Pitcheri* is extremely interesting, as giving the succession of beds with lithological character, more in detail than has elsewhere been published from that region.†

The results at which I have arrived in regard to the identity of the western and southwestern cretaceous formations, may be more clearly appreciated by a comparison of sections of the Upper Missouri and of the same formations on the line of the Boundary Survey.

*Section of the Llano Estacado, and the Prolongation of the same beds to the southward.*

4. Tertiary sandstone, conglomerates, etc., with clays and impure limestones. (Resting unconformably upon the strata below.)

3. Dark colored argillaceous limestone, frequently composed largely of broken shells, and containing *Exogyra costata*.‡

2. Yellow or buff colored limestone, arenaceous limestone, clays, &c., with *Inoceramus problematicus*, *Gryphæa Pitcheri*, *Ammonites Texanus*, *Toxaster Texanum*, *Pyrina Parryi*, &c.

1. Sandstones and clays, of a white, gray, or red color, containing few or no fossils, in the southwest.

*Section of the beds, seen on the Missouri River, from Dixon's Bluff to Fort Pierre, and thence to the Mauvaises Terres.*

4. Tertiary sandstones, conglomerates, argillaceous limestone, clay, &c.

3. Light colored calcareous clay, and dark colored astringent clay, with nodules of limestone. (This includes Nos. 4 and 5 of the original Nebraska section.)

2. Gray or buff-colored, and blue or lead-colored argillaceous limestone, clay, etc., containing *Inoceramus problematicus*, *Ammonites*, &c. (This include Nos. 2 and 3 of the original Nebraska section.)

* The specimens from Pyramid Mouutain are figured in the report of the survey of the 35th Parallel, chap. ix; and those of the Boundary Survey will be found in the present volume. The Ostrea which usually accompanies the *Gryphæa Pitcheri* is *O. subovata* of Shumard.

† For local sections in detail, of the formation No. 1, see Report of the Boundary Survey.

‡ It is quite probable that these beds may not be separable in all cases, from those below, and I am now informed (May 1857) by Dr. G. G. Shumard that he finds *Exogyra costata* extending throughout the fossiliferous cretaceous strata of New Mexico.

1. Sandstones and clays, white, gray or brown, in irregular and unequal alternating beds; containing few fossils except fragments of carbonized wood.

I can therefore only regard the sandstone of the southwest, or at least a large part of it, as identical in age, and a prolongation of the formation No. 1 of Nebraska; and which from the evidence of its cretaceous character, and the absence of any evidence to the contrary, must be referred to the cretaceous period.

---

## Art. VIII.—*Researches on the Ammonia-cobalt Bases;* by Wolcott Gibbs and F. A. Genth. Part I.

Concluded from vol. xxiii, p. 341.

### XANTHOCOBALT.

The salts of Xanthocobalt may be prepared by two distinct processes, either directly from ammoniacal solutions of salts of cobalt, or from neutral, acid, or ammoniacal solutions of the salts of Roseocobalt or Purpureocobalt. In any case, the gas arising from the action of nitric acid upon starch or sawdust, and which may be considered as a mixture of $CO_2$, $NO_2$, $NO_3$, and $NO_4$—the last probably in excess—is to be passed into the solution. A more or less rapid absorption accompanied by copious fumes of carbonate of ammonia takes place. The color of the liquid gradually changes to a dark reddish-brown or dark sherry-wine color, and the liquid on cooling generally deposits an abundance of a salt of Xanthocobalt in brown-yellow crystals. When a current of the red gas above mentioned, and which we shall denote by the symbol $NO_x$, is passed into an acid solution of cobalt and ammonia, an absorption also usually takes place, but in this case no Xanthocobalt is produced, but only a beautiful yellow crystalline salt, which is the ammonia nitrite of cobalt, corresponding to the yellow potash salt, first described by Fischer,* some years afterward re-discovered and analyzed by St. Evre,† and finally examined by Stromeyer.‡ The formation of this compound is easily prevented, by keeping the solution ammoniacal by constant additions of ammonia.§

* Pogg. Ann., lxxiv, 115, and lxxxviii, 496.

† Compt. Rend., xxxiv, 479, and Ann. de Chimie et de Physique, xxxviii, 177.

‡ Journ. für Pract. Chemie, lxi, 41, and Annalen der Chemie und Pharmacie, xcvi, 218.

§ The employment of the double nitrite of cobalt and potash as a means of separating cobalt from other metals was first suggested by Fischer, and afterward by St. Evre and Stromeyer. As the salt is insoluble in a solution of acetate of potash and in alcohol, it is easy to wash it completely, but after washing it is difficult to estimate the cobalt accurately by drying and weighing upon a filter. We have found that a very satisfactory result may be obtained by weighing the cobalt in the

The salts of Xanthocobalt have a dark sherry-wine or brown-yellow color. They are rather more soluble, both in hot and cold water, than the salts of Roseocobalt, Purpureocobalt, or Luteocobalt, the solutions when dilute have a yellow color; when concentrated they are dark-brown yellow. Solutions of these salts are decomposed by boiling, though sometimes with difficulty; in some cases, however, a temperature much below the boiling point produces an incipient decomposition after a short time, so that great care must be taken in evaporating for the purpose of crystallization. During the decomposition by boiling, ammonia is given off, while a heavy black or dark-brown powder is thrown down. The addition of a mineral acid prevents the decomposition, but produces, even when in very small quantity, a chemical change of a different kind, deutoxyd of nitrogen being given off, while a salt of Purpureocobalt is formed, which remains mixed with the undecomposed salt of Xanthocobalt, and which it is difficult to separate. A few drops of acetic acid, however, added to a solution of a salt of Xanthocobalt, so as to produce a slightly acid reaction, will usually suffice to prevent decomposition, if the solution be evaporated at a gentle heat. The dry salts of Xanthocobalt heated in a porcelain crucible are easily decomposed, with copious evolution of red vapors, and afterwards of ammonia, while a black powder remains. We have not been able to detect any new ammonia-cobalt bases among the products of the decomposition of solutions of these salts, by simple boiling or heating in the dry way.

Xanthocobalt differs from the other ammonia-cobalt bases by containing deutoxyd of nitrogen as a couplet in addition to ammonia. Considering it as a primary radical, we attribute to it the formula $NO_2.5NH_3.Co_2$, and it is evident that it differs from Roseocobalt and Purpureocobalt only by one equivalent of deutoxyd of nitrogen. The passage of the salts of these two

form of mixed sulphates of cobalt and potash. According to Stromeyer, Fischer's salt has the formula

$$Co_2O_3.2NO_3+3KO, NO_3+2HO.$$

When this is heated with sulphuric acid till the excess of acid is expelled, there remains a mixture of sulphates having the formula

$$2CoO, SO_3+3KO, SO_3.$$

We, therefore, dry the salt carefully, burn the filter upon the cover of a deep platinum crucible, and bring the ashes and salt into the crucible itself. A few drops of sulphuric acid are then added, so as to cover the mass, and the whole is then treated precisely as we described on page 237, though in this case a higher heat is to be used. From the weight of the mixed sulphates the quantity of cobalt is easily calculated. This method gives very accurate results, because the cobalt forms only about 14 per cent of the substance weighed. In an experiment made to test the accuracy of Stromeyer's formula

0·6671 grs. gave 0·6437 grs. mixed sulphates of cobalt and potash = 13·66 per cent cobalt.

The formula requires 13·63 per cent.

bases into salts of Xanthocobalt by the simple absorption of $NO_2$ is thus easily explained, as is the decomposition of the salts of Xanthocobalt into $NO_2$ and salts of Purpureocobalt.

It is, however, proper to remark that, inasmuch as the salts of Xanthocobalt which we have examined in all cases appear to contain water in the proportion of at least one equivalent, it is possible that the view we have taken of their constitution may not be precisely accurate, and that they may contain $NO_3$ as a couplet in place of $NO_2$. This will be evident from a simple inspection of the formulæ of the chlorid, nitrate, and sulphate of Xanthocobalt, which are, as we write them at present

$$NO_2.5NH_3.Co_2O, Cl_2+HO.$$
$$NO_2.5NH_3.Co_2O_3, 2NO_5+HO.$$
$$NO_2.5NH_3.Co_2O_3, 2SO_3+HO.$$

No chemical analyses could, probably, in substances of such high equivalents, enable us to say with certainty that there may not be in these formulæ an equivalent of hydrogen too much. In this case the three formulæ would read

$$NO_3.5NH_3.Co_2O, Cl_2.$$
$$NO_3.5NH_3.Co_2O_3, 2NO_5.$$
$$NO_3.5NH_3.Co_2O_3, 2SO_3.$$

The difficulty of analyzing these salts must also be fairly considered in forming an opinion as to their constitution. We adopt provisionally the formula first given, in the hope that a more extended study of the products of decomposition will enable us hereafter to fix the constitution with certainty. In the mean time, we will only remark, that the analyses of the nitrate of Xanthocobalt, which is of all salts of the base the easiest to prepare in a state of absolute purity, correspond exactly to the formula

$$NO_2.5NH_3.Co_2O_3, 2NO_5+HO.$$

### CHLORID OF XANTHOCOBALT.

The chlorid of Xanthocobalt can be most readily prepared by decomposing a solution of the sulphate by chlorid of barium. After separation of the sulphate of baryta by filtration, a few drops of acetic acid may be added to the filtrate, which, after evaporation by a gentle heat, will yield on standing large crystals of the chlorid. This process is in fact the only one by which we have been able as yet to prepare this salt.

The chlorid of Xanthocobalt cannot be prepared by the direct action of a current of $NO_x$ upon an ammoniacal solution of the chlorid of cobalt. It is true that in this case an abundance of a brown-yellow crystalline salt is obtained, which might easily be mistaken for the chlorid. The salt is, however, a mixture of a large quantity of the nitrate of Xanthocobalt with a much

smaller quantity of another salt, which appears to be the chlorid of a distinct base, but which is not yet fully studied.*

The equation which represents the formation of the chlorid of Xanthocobalt by double decomposition, is simply

$$NO_2.5NH_3.Co_2O_3, 2SO_3 + 2BaCl = 2BaO, SO_3 + NO_2.5NH_3.Co_2O, Cl_2$$

The chlorid of Xanthocobalt crystallizes in brown-yellow crystals, which when large, have a faint reddish tinge. They are usually very well defined, and exhibit a beautiful iridescence upon their surfaces, but we cannot at present describe their form. The salt is quite soluble in hot water, but the solution is easily, though only partially, decomposed at a boiling heat, and even, when quite neutral, at a lower temperature. On boiling, ammonia is evolved in abundance, while a heavy black precipitate is thrown down; it requires very long boiling to produce a complete decomposition. The salt is rather insoluble in cold water; chlorhydric acid precipitates it unchanged in the cold, and the same effect is produced by the solutions of the alkaline chlorids. Acids, even when dilute, easily and completely decompose the chlorid of Xanthocobalt by boiling. Chlorhydric acid in large excess, by long boiling, converts the salt completely into chlorid of Purpureocobalt, deutoxyd of nitrogen, and occasionally chlorine, being given off. Sulphuric and nitric acid also decompose the chlorid, but with these acids the decomposition generally goes so far as to produce salts of cobalt, or double salts of cobalt and ammonia. Oxalic acid also produces complete decomposition by long boiling, oxalate of cobalt and oxalate of ammonia being formed. Even strong acetic acid produces, on boiling with the salt, a partial decomposition. Alkalies readily decompose a solution of the chlorid when heated, ammonia being evolved, while a black powder is thrown down. The dry chlorid is easily decomposed below a red heat. An abundance of red vapors is at first given off, afterward ammonia is evolved, and finally a black superoxyd of cobalt remains.

Reducing agents, in certain cases, completely decompose the solution of the chlorid of Xanthocobalt, giving salts of cobalt and ammonium. Thus a current of sulphydric acid gas passed for some time through the solution gives a precipitate of sulphur and sulphid of cobalt, while nitrogen gas escapes, and chlorid and sulphid of ammonium remain in solution. The decomposition is similar in an acid solution, but of course no sulphid of cobalt is precipitated.

We made this experiment in the hope of decomposing the $NO_2$ in the chlorid in a manner similar to the well known reac-

* It is this chlorid in an impure state to which, in my Report on the Recent Progress of Organic Chemistry, the formula $2NO_2.5NH_3.Co_2O_2Cl$, is attributed, and which is there called Dixanthocobalt.—W. G.

tion in the case of organic compounds containing $NO_4$. For the same reason we also boiled the chlorid with acetic acid and iron filings, in the hope of obtaining a reaction analagous to that which is produced under the same circumstances with nitro-benzol, nitro-naphtalin, &c., as observed by Béchamp. The experiments, however, led to no interesting result.

Chlorid of Xanthocobalt has the formula

$$NO_2.5NH_3.Co_2O, Cl_2+HO,$$

as the following analyses show:

0·2652 grs. gave 0·1557 grs. sulphate of cobalt = 22·34 per cent cobalt.
0·5865 grs. gave 0·3435 grs. " " = 22·29 " "
0·8240 grs. gave 0·8980 grs. chlorid of silver = 26·94 " chlorine.
1·5200 grs. gave 1·6740 grs. " " = 27·22 " "
0·4983 grs. gave 0·2773 grs. water = 6·18 " hydrogen.
0·5897 grs. gave 0·3272 grs. " = 6·16 " "
1·0768 grs. gave 297 c. c. nitrogen at 16°·9 C. and $758^{mm}·43$ (at 17°·2 C.) = 273·02 c. c. at 0° and $760^{mm}$ = 31·84 per cent.
1·0657 grs. gave 297 c. c. nitrogen at 19°·5 C. and $763^{mm}·26$ (at 20° C.) = 271·30 c. c. at 0° and $760^{mm}$ = 31·97 per cent.

The formula requires

| | Eqs. | | Calculated. | Mean. | Found. | |
|---|---|---|---|---|---|---|
| Cobalt, | 2 | 59 | 22·52 | 22·32 | 22·34 | 22·29 |
| Chlorine, | 2 | 71 | 27·09 | 27·08 | 26·94 | 27·22 |
| Hydrogen, | 16 | 16 | 6·10 | 6·17 | 6 18 | 6·16 |
| Nitrogen, | 6 | 84 | 32·06 | 31·90 | 31·84 | 31·97 |
| Oxygen, | 4 | 32 | 12·23 | 12·53 | —— | —— |
| | | 262 | 100·00 | | | |

## CHLORAURATE OF XANTHOCOBALT.

This salt is readily formed by adding a solution of terchlorid of gold to one of the chlorid of Xanthocobalt. Beautiful yellow needles are thrown down, which may easily be purified by re-solution in hot water and crystallization. The chloraurate of Xanthocobalt crystallizes in beautiful brown-yellow iridescent prisms, which belong to the trimetric or right rhombic system, according to Prof. Dana's measurements. The observed forms are $\infty$, $1\text{-}\bar{\infty}$, the only observed angle is $1\bar{\imath} : 1\bar{\imath} = 130° 24'$. $I : I$ varies much and could not be accurately determined.

The formula of this salt is

$$NO_2.5NH_3.Co_2O, Cl_2+AuCl_3+2HO.$$

The data of the analysis are as follows:

0·2687 grs. gave 0·1645 grs. metallic gold and sulphate of cobalt = 10·28 per cent cobalt.
0·3028 grs. gave 0·1035 grs. metallic gold (reduced by $SO_2$) = 34·18 per cent.
0·2749 grs. gave 0·3461 grs. chlorid of silver = 31·12 per cent chlorine.

The formula requires

| | Eqs. | Calculated. | Found. |
|---|---|---|---|
| Cobalt, | 2 | 10·26 | 10·28 |
| Gold, | 1 | 34·28 | 34·18 |
| Chlorine, | 5 | 30·89 | 31·12 |

### CHLORPLATINATE OF XANTHOCOBALT.

This salt is easily prepared by direct combination. It has a fine orange-yellow color, and is with difficulty soluble both in hot and cold water, but it may be re-crystallized from a hot solution in dilute chlorhydric acid. It is represented by the formula

$$NO_2 . 5NH_3 . Co_2O, Cl_2 + 2PtCl_2 + 2HO,$$

as the following analyses show:

0·6830 grs. gave 0·1421 grs. chlorid of cobalt = 9·45 per cent cobalt.
0·6830 grs. gave 0·2187 grs. platinum = 32·02 per cent.

The formula requires

| | Eqs. | Calculated. | Found. |
|---|---|---|---|
| Cobalt, - - - | 2 | 9·52 | 9·45 |
| Platinum, - - | 2 | 31·87 | 32·02 |

The analysis was made in this case by gently igniting the salt in a platinum crucible, and afterwards dissolving out the chlorid of cobalt by long boiling with chlorhydric acid.

### CHLORHYDRARGYRATE OF XANTHOCOBALT.

This salt is formed by adding a cold solution of chlorid of mercury to a solution of the chlorid of Xanthocobalt. It is usually thrown down in the form of brilliant pale brownish-yellow talcose scales, which on re-solution in hot water containing a little free chlorhydric acid, separate as the solution cools in brown-yellow needles. The two forms appear to have the same chemical constitution. The salt is quite insoluble in cold, and with difficulty soluble in hot water, but the solution occurs without sensible decomposition. The chlorhydrargyrate of Xanthocobalt has the formula

$$NO_2 . 5NH_3 . Co_2O, Cl_2 + 4HgCl + 2HO,$$

as the analyses satisfactorily show:

0·7025 grs. gave 0·1375 grs. sulphate of cobalt = 7·44 per cent cobalt.
0·8898 grs. gave 0·9377 grs. chlorid of silver = 26·05 per cent chlorine.

The formula requires

| | Eqs. | Calculated. | Found. |
|---|---|---|---|
| Cobalt, - - - | 2 | 7·25 | 7·44 |
| Chlorine, - - | 6 | 26·19 | 26·05 |

### FERROCYANID OF XANTHOCOBALT.

This salt is precipitated almost immediately when a solution of ferrocyanid of potassium is added to one of the nitrate of Xanthocobalt. We have not been able to obtain it, however, either from the chlorid or the sulphate, with which the ferrocyanid of potassium gives only turbid solutions. The salt is precipitated in prismatic crystals which appear to belong to the oblique rhombic system. Its color is a very beautiful bright

orange-red, corresponding nearly with the red-orange No. 5, of the 2d circle of Chevreul's scale. When freshly prepared, it is one of the most beautiful salts which chemistry can exhibit, but it loses some of its brilliancy of tint by keeping, and becomes a little duller and darker, probably from a slight decomposition upon the surface. The crystals exhibit a fine dichroism by reflection, the ordinary image being pale reddish orange, while the extraordinary image is bright orange. The ferrocyanid of Xanthocobalt is almost insoluble in cold, and is immediately decomposed by hot or even by warm water. The crystals lose water and are partially dissolved in vacuo, or even in pleno over sulphuric acid. They can, therefore, only be dried by pressure between folds of bibulous paper. The impossibility of purifying this salt by recrystallization, and the facility with which it is decomposed, render it difficult to obtain it in a perfectly pure state.

The formula of the ferrocyanid appears to be

$$NO_2 . 5NH_3 . Co_2O,\ Cy_2 + FeCy + 7HO,$$

as the following analyses show:

0·6288 grs. gave 0·1557 grs. metallic cobalt and iron = 24·76 per cent.
0·9047 grs. gave 0·2239 grs. " " " = 24·74 "
0·5896 grs. gave 0·0690 grs. sesquioxyd of iron = 8·19 " iron.
0·6006 grs. gave 0·1311 grs. $Co_2O_3 + 4CoO$ = 16·39 " cobalt.
1·0820 grs. gave 0·4163 grs. carbonic acid = 10·49 " carbon.
1·1645 grs. gave 0·6439 grs. water = 6·14 " hydrogen.
0·8718 grs. gave 271 c. c. nitrogen at 20°·8 C. and 765$^{mm}$·04 (at 21°·3 C.) = 246·51 c. c. at 0° and 760$^{mm}$ = 35·51 per cent.
0·9471 grs. gave 292 c. c. nitrogen at 17°·7 C. and 763$^{mm}$·01 (at 18° C. = 268·96 c. c. at 0° and 760$^{mm}$ = 35·66 per cent.

The formula requires

| | Eqs. | Calculated. | | Found. | | |
|---|---|---|---|---|---|---|
| | | | | 1. | 2. | 3. |
| Cobalt, | 2 | 16·80 | 24·77 | 16·39 | 24·76 | 24·74 |
| Iron, | 1 | 7·97 | | 8·19 | | |
| Carbon, | 6 | 10·25 | | 10·49 | | |
| Hydrogen, | 22 | 6·26 | | 6·14 | | |
| Nitrogen, | 9 | 35·89 | | 35·66 | 35·51 | |

These analyses agree with the formula as well as can be reasonably expected, when the difficulty of obtaining a perfectly pure salt is taken into consideration. It is interesting to remark that in this salt, in which there is but one equivalent of basic cyanid, there are still two equivalents of cyanogen in the basic for one in the acid or electro-negative cyanid.

### SULPHATE OF XANTHOCOBALT.

When pure sulphate of cobalt is dissolved in water, an excess of ammonia added, and a current of $NO_x$ passed through the liquid, an absorption takes place, and copious fumes of carbon-

ate of ammonia are given off. The liquid gradually assumes a dark brown-yellow color, and frequently deposits an abundance of crystals during the passage of the current of gas. Ammonia must be added from time to time, so as to keep the solution strongly alkaline, and prevent the appearance of red vapors at the surface of the liquid. It is not necessary to apply heat, as the temperature rises from the absorption of the gas. When the operation is over, which is indicated by the color of the liquid, the solution may be filtered and allowed to evaporate spontaneously, when a mass of brown-yellow crystals is obtained. These may be purified by re-solution in hot-water with addition of a few drops of acetic acid and re-crystallization.

This method of preparing the salt is a convenient one, and large quantities may be prepared in a few hours. The time required for the completion of the oxydation depends upon the quantity of sulphate of cobalt employed, and may last from one to twelve hours. It is best to employ a rapid current of the gas. The formation of the sulphate of Xanthocobalt, under these circumstances, may be represented by the equation

$$2CoO, SO_3 + 5NH_3 + NO_3 = NO_2.5NH_3.Co_2O_3, 2SO_3$$

if we suppose the oxydizing agent to be $NO_3$. If, however, we consider the active agent to be $NO_4$, we may represent the action by the equation

$$2CoO, SO_3 + 6NH_3 + 2NO_4 + HO = NO_2.5NH_3.Co_2O_3, 2SO_3 + NH_4O, NO_5.$$

A large quantity of free nitrite of ammonia is always formed during the process, as we believe, by the direct action of $NO_3$ upon ammonia and water. The addition of an acid to the mother liquor from which the sulphate has crystallized, produces an active effervescence arising from the decomposition of the nitrite of ammonia.

The process which we have indicated has generally proved perfectly satisfactory in preparing the sulphate. It is proper to state, however, that in some experiments, made for the purpose of revision, we obtained by the process above given no sulphate of Xanthocobalt, but only the nitrate. The cause of this we are at present unable to assign, and further experiments are wanting to explain so unexpected a result.

The sulphate of Xanthocobalt crystallizes in thin plates, the form of which we have not been able to determine; they appear to belong to the right rhombic system. The crystals have a fine brown-yellow color, which, however, we cannot define by means of the chromatic scale. The salt is rather soluble in hot, but much less soluble in cold water. Heat readily decomposes the neutral solution, a black powder being thrown down, while ammonia is given off. The dry salt is decomposed like the chlorid.

Strong sulphuric acid dissolves the sulphate to a red oily liquid, but little deutoxyd of nitrogen being given off. The addition of water to this solution causes a violent effervescence from the escape of deutoxyd of nitrogen, and probably nitrous acid. There remains a red liquid consisting chiefly of the double sulphate of cobalt and ammonia, but almost always containing a little acid sulphate of Purpureocobalt. Even very dilute sulphuric acid readily decomposes sulphate of Xanthocobalt by boiling. Long boiling with chlorhydric acid also decomposes this salt, the products of the decomposition being, as already stated, chlorid of Purpureocobalt, free sulphuric acid, and deutoxyd of nitrogen.

Sulphate of Xanthocobalt has the formula

$$NO_2 . 5NH_3 . Co_2O_3, 2SO_3 + HO$$

as the following analyses show:

0·5776 grs. gave 0·3142 grs. sulphate of cobalt = 20·69 per cent cobalt.
0·5630 grs. gave 0·3060 grs. " " = 20·68 " "
1·2370 grs. gave 1·0150 grs. sulphate of baryta = 28 16 " sulphuric acid.
1·1472 grs. gave 0·9242 grs. " " = 27 65 " " "
0·7713 grs. gave 0·3868 grs. water = 5·56 " hydrogen.
0·4468 grs. gave 0·2285 grs. " = 5·68 " "
0·6020 grs. gave 169·48 c. c. nitrogen at 14° C., and 769$^{mm}$·61 (h = 91$^{mm}$) = 140·87 c. c., at 0° and 760$^{mm}$ = 29·37 per cent.
1·2624 grs. gave 300 c. c. nitrogen at 5° C., and 775$^{mm}$·20 (at 5°·3 C.) = 296·68 c. c., at 0° and 760$^{mm}$ = 29·51 per cent.

The formula requires

| | Eqs. | | Calculated. | Mean. | Found. | |
|---|---|---|---|---|---|---|
| Cobalt, | 2 | 59 | 20·55 | 20·68 | 20·69 | 20·68 |
| Sulphuric acid, | 2 | 80 | 27·94 | 27·90 | 27·65 | 28·16 |
| Hydrogen, | 16 | 16 | 5·57 | 5·62 | 5·56 | 5·68 |
| Nitrogen, | 6 | 84 | 29·26 | 29·44 | 29·37 | 29·51 |
| Oxygen, | 12 | 96 | 16·68 | 16·30 | —— | —— |
| | | 335 | 100·00 | | | |

A solution of sulphurous acid dissolves sulphate of Xanthocobalt without decomposition. On boiling, however, a complete decomposition takes place, bubbles of gas are given off, and there remains a red solution of the double sulphate of cobalt and ammonia. The gas which is evolved produces no red vapors on contact with the air, and is probably protoxyd of nitrogen. The sulphate of Xanthocobalt is also decomposed by boiling with urea, an abundance of a colorless gas without odor being given off. The reactions of the sulphate are similar to those of the chlorid.

### NITRATE OF XANTHOCOBALT.

The nitrate of Xanthocobalt may be prepared like the sulphate, by passing a current of $NO_x$ into an ammoniacal solution of nitrate of cobalt. The formation of the nitrate goes on very

rapidly, and crystals are usually deposited in abundance long before the oxydation is complete. It is best in this case, as in the preparation of the sulphate, to employ a pure salt of cobalt and pure ammonia, as the subsequent purification of the nitrate of Xanthocobalt becomes much more easy. The equations representing the formation of the nitrate are similar to those which we have given for the sulphate.

The nitrate of Xanthocobalt may also be easily prepared by the action of $NO_x$ upon neutral, acid, or alkaline solutions of the chlorids, sulphates and nitrates of Roseocobalt and Purpureocobalt. We have alluded to the formation of the nitrate of Xanthocobalt by this process already, and will here enter more into detail.

It is almost a matter of indifference which salt is selected, as the nitrate is prepared with nearly equal facility from all. The salt is to be dissolved in water, and to hasten the process, ammonia added; a large excess of ammonia is not necessary, but the process always goes on more rapidly in an ammoniacal than in an acid or neutral solution. The current of gas resulting from the action of nitric acid upon starch or sawdust is then to be passed into the liquid, which speedily becomes hot and gradually changes its color from violet to orange-red, and at last to orange, while orange-yellow crystals of the nitrate of Xanthocobalt are precipitated. The liquid on cooling gives more crystals; the process should not be continued after the whole mass has assumed a clear orange-yellow color. The mother-liquor from which the crystals of the nitrate of Xanthocobalt have separated contains only salts of ammonia, with a little nitrate in solution. The whole process is very easy to execute, and yields a very pure nitrate. The reactions which occur in this process are remarkably beautiful, and may be expressed, in the case of the action of the gas upon the chlorid and sulphate of Roseocobalt, by the equations

$$5NH_3.Co_2Cl_3 + 3NO_4 + 3HO = NO_2.5NH_3.Co_2O_3,\ 2NO_5 + 3HCl,$$

$$5NH_3.Co_2O_3,\ 3SO_3 + 3NO_4 + 3HO = NO_2.5NH_3.Co_2O_3,\ 2NO_5 + 3HO,\ SO_3.$$

It will be seen from these equations that when neutral solutions of the salts of Roseocobalt or Purpureocobalt are employed, chlorhydric and sulphuric acids are set free. The influence of an excess of ammonia in facilitating the process is thus easily understood. The nitrate of Xanthocobalt, being much less soluble in cold water than the ammonia salts, is easily purified by re-crystallization. In treating of the sulphate and chlorid of Xanthocobalt, we have mentioned that the nitrate of Xanthocobalt is often formed while preparing these salts directly. As a mode of preparation, this method is not to be recommended, but it possesses much theoretical interest. The equation which

represents the action when the nitrate of Xanthocobalt is formed directly by the action of $NO_x$ upon an ammoniacal solution of the sulphate of cobalt, is possibly the following

$$2CoO, SO_3 + 7NH_3 + NO_3 + 3NO_4 + 2HO = NO_2 . 5NH_3 . Co_2O_3, 2NO_5 + 2NH_4O, SO_3 + NO_2.$$

When the chlorid of cobalt is employed instead of the sulphate, other products are always formed simultaneously with the nitrate of Xanthocobalt, and the reaction becomes therefore more complicated.

The nitrate of Xanthocobalt crystallizes in small brilliant crystals, which, according to Prof. Dana's measurement, belong to the dimetric system. The only form observed as yet is an octahedron, the angle at the base being 100° 45′—101° 15′.

The salt is dichrous, the ordinary image being pale orange, while the extraordinary is bright orange-yellow.

The salt has a clear brown-yellow color, and the mass of crystals is usually very brilliant. It is quite soluble in hot, but rather insoluble in cold water; the solution is readily decomposed by boiling, with evolution of ammonia and precipitation of a heavy black powder. The dry salt is readily decomposed by heating, abundance of red vapors being given off, while a black oxyd remains. The nitrate is completely decomposed by boiling with chlorhydric acid, red vapors mixed with chlorine being given off, while there remains a solution of Purpureocobalt, from which crystals of this salt are deposited on cooling. When boiled with nitric acid, a similar decomposition is produced, and crystals of nitrate of Roseocobalt are obtained in small quantity. It is probable that nitrate of Purpureocobalt is the first product of this reaction, and that this by boiling with excess of acid, passes into the nitrate of Roseocobalt. As a general rule, the quantity of nitrate of Roseocobalt produced is small, and the decomposition results in the conversion of the nitrate of Xanthocobalt into the nitrates of cobalt and ammonia.

Nitric acid precipitates nitrate of Xanthocobalt from its solution without sensible decomposition in the cold. By long boiling acetic acid completely reduces nitrate of Xanthocobalt, and a solution of cobalt is obtained which is free from ammonia-cobalt bases. Oxalic acid also reduces the nitrate by boiling, oxalate of cobalt being thrown down.

Nitrate of Xanthocobalt has the formula

$$NO_2 . 5NH_3 . Co_2O_3, 2NO_5 + HO$$

as the following analyses appear to show:

| | | | | |
|---|---|---|---|---|
| 0 3917 grs. gave 0·1927 grs. | sulphate of cobalt | = 18·72 | per cent | cobalt. |
| 0·6960 grs. gave 0·3405 grs. | " " | = 18·76 | " | " |
| 0·5935 grs. gave 0·2925 grs. | " " | = 18·75 | " | " |
| 0·5585 grs. gave 0·2535 grs. | water | = 5·04 | " | hydrogen. |
| 0·4958 grs. gave 0·2330 grs. | " | = 5·21 | " | " |
| 0·9483 grs. gave 0·4270 grs. | " | = 5·09 | " | " |

0·6145 grs. gave 187·45 c. c. nitrogen at 6°·5 C., and 769$^{mm}$·5 (at 7° C.), (h = 35$^{mm}$·0) = 174·55 c. c. at 0° and 760$^{mm}$ = 35·73 per cent.
0·6024 grs. gave 283·30 c. c. of nitrogen at 5° C., and 759$^{mm}$·9 (at 6° C.), (h = 37$^{mm}$·0) = 169·20 c. c. at 0° and 760$^{mm}$ = 35·27 per cent.
0·5912 grs. gave 184·66 c. c. nitrogen at 11°·5 C., and 761$^{mm}$·0 (at 12° C.), (h = 32$^{mm}$·5) = 167·13 c. c. at 0° and 760$^{mm}$ = 35·50 per cent.

Hence we have

| | Eqs. | Calculated. | | Mean. | Found. | | |
|---|---|---|---|---|---|---|---|
| Cobalt, | 2 | 59·0 | 18·73 | 18·74 | 18·76 | 18·72 | 18·75 |
| Hydrogen, | 16 | 16·0 | 5·08 | 5·11 | 5·04 | 5·21 | 5·09 |
| Nitrogen, | 8 | 112·0 | 35·55 | 35·50 | 35·73 | 35·50 | 35·27 |
| Oxygen, | 16 | 128·0 | 40·64 | 40·55 | —— | —— | —— |
| | | 315·0 | 100·00 | 100·00 | | | |

As the nitrate of Xanthocobalt is, of all the salts of this base, that which is most easily prepared in a state of purity, and as its reactions are most characteristic of the base, we shall give them in this place.

Chlorhydric acid in excess gives a buff-yellow precipitate.

Alkaline carbonates give no precipitate.

Ferrocyanid of potassium precipitates beautiful orange-red crystals.

Ferridcyanid of potassium gives no precipitate.

Cobaltidcyanid of potassium gives no precipitate.

Chromate of potash gives a fine clear yellow precipitate.

Bichromate of potash gives beautiful orange-red needles.

Oxalate of ammonia gives a voluminous precipitate of pale yellow needles.

Picrate of ammonia gives beautiful clear yellow needles.

Phosphate of soda gives no precipitate.

Pyrophosphate of soda gives no precipitate.

Chlorid of mercury gives a buff-colored scaly precipitate.

Protochlorid of tin gives, after a short time, granular yellow crystals.

Bichlorid of platinum gives a orange-yellow precipitate.

Terchlorid of gold gives, after addition of chlorhydric acid and standing, yellow needles.

Iodid and bromid of potassium give no precipitates.

### OXALATE OF XANTHOCOBALT.

The oxalate of Xanthocobalt is precipitated when a solution of oxalate of ammonia is added to one of the chlorid, nitrate or sulphate of the base. After a very short time yellow acicular crystals make their appearance, the separation being greatly facilitated by strongly agitating the solution. The precipitate is to be thrown on a filter, well washed with cold water and dried, first by pressure and afterwards in pleno over sulphuric acid. As thus prepared, the salt has a pale yellow color, and consists of fine needles, the form of which cannot be determined, even

under the microscope. It is nearly insoluble in cold and but very slightly soluble in hot water. The solution is readily decomposed by boiling. The insolubility of this oxalate and its characteristic appearance render it of great value in detecting the presence of salts of Xanthocobalt.

Oxalate of Xanthocobalt has the formula

$$NO_2.5NH_3.Co_2O_3,\ 2C_2O_3+5HO$$

as appear from the following analyses:

0·3191 grs. gave 0·1762 grs. sulphate of cobalt = 21·01 per cent cobalt.
0·2980 grs. gave 0·1650 grs. " " = 21·06 " "
2·2520 grs. gave 0·7075 grs. carbonic acid = 25·70 " oxalic acid.
2·2850 grs. gave 0·7260 grs. " " = 25·99 " " "

The calculated results are

| | Eqs. | Theory. | Found. | |
|---|---|---|---|---|
| Cobalt, | 2 | 21·14 | 21·01 | 21·06 |
| Oxalic acid, | 2 | 25·81 | 25·70 | 25·99 |

## THEORETICAL CONSIDERATIONS.

The empirical constitution of the ammonia-cobalt bases being, as we believe, established, it remains to offer an exposition of our views of their theoretical structure. Claudet* and Weltzien† have endeavored to reduce the salts of Roseocobalt and Luteocobalt to the type of ammonium, while Frémy has abstained from adopting any particular theory, and gives, without comment, the results of his analyses in the shape of empirical formulæ. Claudet's view is necessarily erroneous, from the fact that his formula for what we term the chlorid of Purpureocobalt is incorrect, inasmuch as he assigns to it 16 in place of 15 equivalents of hydrogen. Our own numerous analyses, as well as those of Rogojski and Gregory, have clearly shown that the number of equivalents of hydrogen is fifteen.

For an exposition of Weltzien's views we must refer to his paper; they appear to us wanting in simplicity, since they require us to admit, not merely an equivalent replacement of hydrogen by ammonium and cobalt, but even that the compound ammonium thus formed may replace cobalt in its sesqui-combinations. Thus, according to Weltzien, the formula of nitrate of Luteocobalt is

$$\left.\begin{matrix} N\{H \\ N\{NH_4 \\ N\{NH_4 \\ Co \\ N\{H \\ N\{NH_4 \\ N\{NH_4 \\ Co \end{matrix}\right\} O_3+3NO_5$$

which is obviously reducible to the type $R_2O_3+3NO_5$.

* Phil. Mag. (4) ii, 253.
† Annalen der Chemie und Pharmacie, xcvii, 19.

By adopting Gerhardt's view of the constitution of the sesquioxyds, Rogojski reduces the formula of chlorid of Luteocobalt, $6NH_3.Co_2Cl_3$, for the form $2NH_3.coCl$ in which co represents cobalt with $\frac{2}{3}$ of its usually received equivalent. To this body he gives the name Dicobaltinamin, and considers it analogous to to the chlorids of Diplatosamin and Palladiamin $2NH_3.PtCl$ and $2NH_3.PdCl$. This view applies very well to several other salts of Luteocobalt, as for example, the bromid, iodid, nitrate, and chlorplatinate, the formulæ of which become

$2NH_3.coBr$ or $N_2H_5co$, HBr
$2NH_3.coI$ or $N_2H_5co$, HI
$2NH_3.coO$, $NO_5$ or $N_2H_5co$, HO, $NO_5$
$2NH_3.coCl+PtCl_5+2HO$ or $N_2H_5co$, $HCl+PtCl_2+2HO$.

We have remarked already that the compound $6NH_3.Co_2Cl_3+6NH_3.Co_2O_3$, $3SO_3$, which Rogojski describes, and to which he attributes the formula

$2NH_3.coCl+2NH_3.coO$, $SO_3$, or $N_2H_5co$, $HCl+SO_4H_2$, $2N_2H_5co$.

has no real existence, but is merely a mixture of the chlorid and sulphate which are isomorphous salts. Rogojski's parallel between this and the sulphate of Gros's base, which according to Gerhardt's view has the formula

$N_2H_4pt_2$, $2HCl+N_2H_4pt_2$, $SO_4H_2$

is consequently illusory.

On the other hand, moreover, it must be remembered that Rogojski's view applies only to the compounds of Luteocobalt, and fails entirely to reduce the formulæ of the other cobalt bases to more simple expressions, since it requires us, in these cases, to admit fractions of equivalents. Thus the formula of the chlorid of Purpureocobalt becomes on this view

$$N_{\frac{5}{3}}H_5coCl,$$

while that of its chlorplatinate must be written

$$3N_{\frac{5}{3}}H_5coCl+2PtCl_2.$$

Even in the case of those compounds of Luteocobalt which contain water, Rogojski's view ceases to give simple expressions, since in the majority of these the number of equivalents of water is not divisible by three. The difficulty becomes still greater in the case of the compounds of Xanthocobalt. We have, therefore, no hesitation in rejecting Rogojski's theory as too limited in its application.

We consider the ammonia-cobalt bases as conjugate compounds of sesquioxyd, sesquichlorid, &c., of cobalt, the five or six equivalents of ammonia, or of ammonia and deutoxyd of nitrogen, forming the conjunct, and serving to give to the sesquicompound of cobalt the degree of stability which it possesses in

this class of bodies. Accordingly we should prefer to write the formula of chlorid of Luteocobalt

$$6\overset{\frown}{NH_3}.Co_2.Cl_3$$

employing the connecting circumflex, as Kolbe has suggested, as a symbol of conjugation. Adopting this view, we have the following conjugate radicals, which we assume as existing in the ammonia-cobalt bases precisely in the same sense in which we assume $Co_2$ as existing in the sesquichlorid and sesquioxyd of cobalt.

| | |
|---|---|
| Roseocobalt, - - - - | $5NH_3.Co_2$ |
| Purpureocobalt, - - - | $5\overset{\frown}{NH_3}.Co_2$ |
| Luteocobalt, - - - - | $6\overset{\frown}{NH_3}.Co_2$ |
| Xanthocobalt, - - - | $\overset{\frown}{NO_2}.5\overset{\frown}{NH_3}.Co_2$. |

We may, however, remark that while this view offers a satisfactory explanation of the fact that two of the ammonia-cobalt bases are triacid, forming in all cases neutral compounds with three equivalents of acid, two are biacid bases, and of these latter, one, namely Purpureocobalt, forms acid compounds with four equivalents of acid.

In these cases we meet with the same difficulty which occurs with the ordinary salts of sesquioxyds; thus sesquioxyd of iron may unite with one, two, or three equivalents of acid, though there appear to be three in the neutral salts. While some chemists assume that salts of sesquioxyd of iron containing one or two equivalents of acid are basic, others consider the different equivalents of oxygen as united in different modes, so that the oxyd may be, according to circumstances,

$$Fe_2O_3$$
$$Fe_2O_2.O$$
$$Fe_2O.O_2.$$

Peligot's theory of the constitution of sesquioxyd of uranium is another case in point; as this oxyd unites with but a single equivalent of acid, it may be considered, as Peligot has shown, as the oxyd of a radical, $U_2O_2.O$, so that in this case also, the rule that a base unites with as many equivalents of acids as the base itself contains equivalents of oxygen is satisfied.

To explain the biacid character of two of the ammonia-cobalt bases, we may therefore assume in them the existence of secondary radicals containing oxygen. Thus in Purpureocobalt and Xanthocobalt the primary radicals are

$$5\overset{\frown}{NH_3}.Co_2$$
$$\overset{\frown}{NO_2}.5\overset{\frown}{NH_3}.Co_2;$$

while the secondary radicals are

$$5\overset{\frown}{NH_3}.Co_2O$$
$$\overset{\frown}{NO_2}.\overset{\frown}{5NH_3}.Co_2O.$$

The oxyds on this view are

$$5\overset{\frown}{NH_3}.Co_2O.O_2$$
$$\overset{\frown}{NO_2}.\overset{\frown}{5NH_3}.Co_2O.O_2$$

and are consequently of the form $RO_2$, so that their biacid character is explained. The doctrine of polyacid bases is by no means new; it is in fact contained in the empirical law above referred to, that there are in neutral salts as many equivalents of acid as there are of oxygen in the base, bearing in mind, however, that the oxygen in the base must be outside of the radical. The ammonia-cobalt bases like the conjugate metals produced by the union of ethyl, methyl, &c., with antimony, arsenic, and bismuth, serve, however, to place the doctrine of polyacid bases upon the same footing as that of the polybasic acids, so that the two theories are in this way complementary to each other. From this point of view it is interesting to remark, that the chlorplatinates and double cyanids of the ammonia-cobalt bases follow the same law as the oxygen salts, thus we have

$$6NH_3.Co_2Cl_3 + 3PtCl_2$$
$$5NH_3.Co_2Cl.Cl_2 + 2PtCl_2$$
$$NO_2.5NH_3.Co_2O.Cl_2 + 2PtCl_2$$
$$6NH_3.Co_2Cy_3 + Co_2Cy_3$$
$$NO_2.5NH_3.Co_2O.Cy_2 + FeCy.$$

In point of fact, the presence of but two equivalents of bichlorid of platinum in the chlorplatinate of Purpureocobalt first led us to suspect that the true oxygen salts of this base would be found to contain but two equivalents of acid.

Two other points require special notice in this connection. We have already shown that the oxyd of Purpureocobalt, in at least two cases, is capable of uniting with *four* equivalents of acid so as to form feebly acid salts. We consider these salts the true bi-salts of the base, and not as double salts of Purpureocobalt and water. In other words, we hold that they bear the same relation to the neutral salts of the base which bichromate of potash does to the neutral chromate. If this view be correct, we may perhaps expect to find salts of Roseocobalt or Luteocobalt containing *six* equivalents of acid. The only acid salt of Luteocobalt hitherto discovered is the carbonate, but this in reality, in our view, is a double salt of Luteocobalt and water, and has the formula

$$6NH_3.Co_2O_3, 3CO_2 + HO, CO_2.$$

The fact, that both the acid and neutral oxalo-sulphate of Purpureocobalt contain two distinct acids, is also a very instructive one, since it completes the analogy between the polyacid bases and the polybasic acids. A polybasic acid, as, for example, tartaric acid, may unite with two different bases at once, and we now learn that a polyacid base may in like manner unite with two different acids. Thus we have

$$C_8H_4O_{10}\begin{cases}KO\\NaO\end{cases},\quad 5NH_3.Co_2O_3\begin{cases}SO_3\\C_2O_3\end{cases},\quad 5NH_3.Co_2O_3\begin{cases}2SO_3\\2C_2O_3.\end{cases}$$

The other point to which we refer, is the peculiarity in the constitution of Xanthocobalt, in which one equivalent of oxygen in the secondary radical is not capable of replacement by chlorine, so that we have for the chlorid of this base the formula

$$\overbrace{NO_2}.\overbrace{5NH_3}.Co_2O.Cl_2,$$

while for the chlorid of Purpureocobalt, we have

$$\overbrace{5NH_3}.Co_2Cl.Cl_2$$

and not, as we might expect from the analogy of Xanthocobalt,

$$\overbrace{5NH_3}.Co_2O.Cl_2.$$

The appearance of deutoxyd of nitrogen as a conjunct (Paarling) is in itself well worthy of attention, and Xanthocobalt forms, we believe, the only known instance in which this occurs. It seems *à priori* probable, that iridium and rhodium bases corresponding to Xanthocobalt may be prepared by passing a current of $NO_x$ into ammoniacal solutions of protosalts of those metals, or into solutions of Claus' bases, and we have already instituted experiments with these metals, the results of which we hope hereafter to communicate.

The theory which we have proposed for the ammonia-cobalt bases has also been brought forward by Claus, and applied to his rhodium and iridium compounds. Claus has extended the view in question to the ammonia compounds of metallic protoxyds, and we conceive with advantage, in the case of those bases which contain more than one equivalent of ammonia, as for instance, the platinum, palladium, and iridium bases, having the formulæ

$2NH_3.PtO$ $2NH_3.PdO$ $2NH_3.IrO.$

The discovery of the biacid character of Purpureocobalt and Xanthocobalt, in connection with the views which we have expressed with respect to the molecular structure of these bases, has led us to extend the theory of conjugation to the ammonia-platinum compounds. We consider these also as conjugate bases, and are of opinion that their constitution may be more simply expressed upon this than upon any other view yet pro-

posed. The ammonia-platinum bases at present known are eight in number, of which two were discovered by Reiset, one by Gros, two by Raewsky, and three by Gerhardt. The empirical formulæ of these bases are as follows:

| | | |
|---|---|---|
| Reieset's first base | $= N_2H_6PtO$ | uniacid |
| " second base | $= NH_3PtO$ | " |
| Gros's base | $= N_2H_6PtClO$ | " |
| Gerhardt's first base | $= NH_3PtO_2$ | " |
| " second base | $= N_2H_6PtO_2$ | " |
| " third " | $= NH_3PtClO$ | " |
| Raewsky's first " | $= N_4H_{12}Pt_2ClO_5$ | biacid |
| " second " | $= N_4H_{12}Pt_2Cl_2O_4$ | " |

If we apply to these bases the results which we have obtained in the case of the ammonia-cobalt compounds, we may consider them as conjugates of platinum, chlorid of platinum, and oxyd of platinum, with one or two equivalents of ammonia, excepting Raewsky's bases, which may be regarded as containing a deutoxyd of chlorine with four equivalents of ammonia. The formulæ of these bases become on this view

| | | | |
|---|---|---|---|
| Reiset's second base | $=$ | $\widehat{NH_3}.Pt.O$ | uniacid |
| Gerhardt's first " | $=$ | $\widehat{NH_3}.PtO.O$ | " |
| " third " | $=$ | $\widehat{NH_3}.PtCl.O$ | " |
| Reieset's first " | $=$ | $2\widehat{NH_3}.Pt.O$ | " |
| Gerhardt's second base | $=$ | $2NH_3.PtO.O$ | " |
| Gros's second base | $=$ | $2\widehat{NH_3}.PtCl.O$ | " |
| Raewsky's first " | $=$ | $ClO_2.\widehat{4NH_3}.Pt_2O.O_2$ | biacid |
| " second base | $=$ | $ClO_2.\widehat{4NH_3}.Pt_2Cl.O_2$ | " |

In comparing the formulæ of these bases with those of the ammonia-cobalt compounds, we remark several points of analogy. These are most striking in the case of Raewsky's two bases, which we consider analogous to Xanthocobalt. Thus we have

| | |
|---|---|
| Oxyd of Xanthocobalt, | $NO_2.\widehat{5NH_3}.Co_2O.O_2$ |
| Oxyd of Raewsky's first base, | $ClO_2.\widehat{4NH_3}.Pt_2O.O_2.$ |

Raewsky's second base contains chlorine in the radical in place of oxygen. We consider it, to say the least, very probable that there exists an analogous cobalt base having the formula

$$NO_2.\widehat{5NH_3}.Co_2Cl.O_2$$

like

$$ClO_2.\widehat{4NH_3}.Pt_2Cl.O_2$$

and we may here remark that the compound which we have mentioned as one of the products of the action of a current of $NO_x$ upon an ammoniacal solution of chlorid of cobalt appears to contain chlorine in the radical, since we have found this ele-

ment in the dark brown-yellow oxalate which is thrown down by oxalate of ammonia from the solution.

The constitution of Gros's base becomes perfectly intelligible upon this view, as does that of the analogous base containing but one equivalent of ammonia. It can scarcely fail to escape notice that the theory of conjugates brings all the platinum bases under one point of view, and exhibits the analogy in their constitution in a very striking manner, by arranging them at once in three groups, of which the first two are exactly parallel. Thus we have for the radicals of the first six bases mentioned the formulæ

| | |
|---|---|
| $NH_3\overset{\frown}{.}Pt$ | $2NH_3\overset{\frown}{.}Pt$ |
| $NH_3\overset{\frown}{.}PtO$ | $2NH_3\overset{\frown}{.}PtO$ |
| $NH_3\overset{\frown}{.}PtCl$ | $2NH_3\overset{\frown}{.}PtCl,$ |

each uniting with a single equivalent of oxygen to form a uni-acid base. The occurrence of a deutoxyd of chlorine as a couplet is not more remarkable or more improbable than that of deutoxyd of nitrogen; but experimental evidence is still wanting to support the view which we have taken of the constitution of Raewsky's bases which have as yet been very imperfectly examined. Claus* has also applied the theory of conjugates to several of the ammonia-platinum bases, but has not considered the subject from precisely the point of view which we have taken, though his ideas, in the main, are the same. It is in the explanation of the difference in the saturating capacity of the various bases that Claus' view appears to us less satisfactory than that which we have proposed. It is scarcely necessary to remark that our theory applies to all bases containing ammonia and a metallic oxyd. We may, however, observe that it also harmonizes perfectly with the ammonium theory if we consider ammonium as a conjugate hydrogen, or as represented by the formula $NH_3\overset{\frown}{.}H$.

We will here remark that our view of the theoretical constitution of the ammonia-cobalt bases was distinctly enunciated in the paper already referred to, as published by one of ourselves, in 1851.

A glance at the formulæ of the ammonia-cobalt bases, suggests the possibility of generalizing the results which we have obtained, by two distinct methods. In the first place, it is evidently possible, theoretically at least, to replace one or more equivalents of ammonia in these compounds by an equal number of equivalents of a compound ammonia, as for example, by methylamin, ethylamin, &c. Thus there may be, for example, a species of Roseocobalt, having the formula

$$5N(C_2H_3)_3\overset{\frown}{.}Co_2,$$

* Chemisch-Pharmaceutisches Central Blatt No. 25, p. 189, Oct. 1854.

which would represent the base which we have described under that name, in which methylamin replaces ammonia. We have not yet been able to investigate this point with any degree of thoroughness, and will here only mention, that an experiment made by adding a solution of piperidin to one of chlorid of cobalt and allowing the solution to stand for some time in a half-filled flask, with frequent agitation, led to no decisive result. We selected piperidin for this experiment, because this alkaloid is comparatively easy to prepare, and does not itself oxydize by exposure to the air.

In the next place, the results of our investigation may be generalized by replacing cobalt by other metals. This, as we have already remarked, has been done by Claus, who obtained ammonia-rhodium and ammonia-iridium bases corresponding to Roseocobalt, and like this, triacid bases. To judge, however, from the imperfect notices of Claus' papers which have hitherto reached us, his compounds are not isomorphous with those of Roseocobalt.

We have ourselves made many experiments in this direction, though as yet without interesting results. Iron and manganese promised to afford similar classes of compounds, yet in their behavior toward ammonia and oxygen the proto-salts of these metals exhibit no analogy to those of cobalt. With chromium the case may be different, but we cannot as yet pronounce with certainty on this point. Experiments with nickel failed entirely, and yielded only ammonia-salts of the protoxyd.

The behavior of ammoniacal solutions of proto-salts of iron and manganese toward the mixture of gases which we have denoted by the formula $NO_x$ is worthy of notice. When tartaric acid is added to a solution of proto-chlorid of iron or manganese, and after the addition of a large excess of ammonia, a rapid current of $NO_x$ is passed through the solution, the liquid soon becomes dark colored, and after a time the whole of the iron or manganese is precipitated as a dark brown or nearly black flocky substance. The filtrate is free from the metal employed. No ammonia-iron or ammonia-manganese base is, however, formed under these circumstances.

In order to afford a general view of the results of our investigation, we will here give a table of the formulæ of the bodies which we have analyzed, or whose constitution has been inferred from analogy of crystalline form.

*Roseocobalt.*

| | |
|---|---|
| Chlorid, - - - - | $5\overset{\frown}{NH_3}.Co_2.Cl_3+2HO.$ |
| Chlorplatinate, - - | $5\overset{\frown}{NH_3}.Co_2.Cl_3+3PtCl_2+8HO.$ (?) |
| Sulphate, - - - | $5\overset{\frown}{NH_3}.Co_2.O_3,\ 3SO_3+5HO.$ |

| | |
|---|---|
| Nitrate, - - - | $5NH_3^{\frown}.Co_2.O_3, 3NO_5.$ |
| Hydrous nitrate, - - | $5NH_3^{\frown}.Co_2.O_3, 3NO_5+2HO.$ |
| Oxalate, - - - | $5NH_3^{\frown}.Co_2.O_3, 3C_2O_3+6HO.$ |
| Ferridcyanid, - - - | $5NH_3^{\frown}.Co_2.Cy_3+Fe_2Cy_3+3HO.$ |
| Cobaltidcyanid, - - | $5NH_3^{\frown}.Co_2.Cy_3+Co_2Cy_3+3HO.$ |

*Purpureocobalt.*

| | |
|---|---|
| Chlorid, - - - - | $5NH_3^{\frown}.Co_2Cl.Cl_2.$ |
| Chlorplatinate, - - | $5NH_3^{\frown}.Co_2Cl.Cl_2+2PtCl_2.$ |
| Acid sulphate, - - - | $5NH_3.Co_2O.O_2, 4SO+5HO.$ |
| Oxalate, - - - | $5NH_3^{\frown}.Co_2O.O_2, 2C_2O_3+3HO.$ |
| Acid oxalo-sulphate, - - | $5NH_3^{\frown}.Co_2O.O_2, 2C_2O_3, 2SO_3+3HO.$ |
| Neutral oxalo-sulphate, - | $5NH_3^{\frown}.Co_2O.O_2, C_2O_3, SO_3+7HO.$ |

*Luteocobalt.*

| | |
|---|---|
| Chlorid, - - - - | $6NH_3^{\frown}.Co_2.Cl_3.$ |
| Iodid, - - - - | $6NH_3^{\frown}.Co_2.I_3.$ |
| Bromid, - - - - | $6NH_3^{\frown}.Co_2.Br_3.$ |
| Chlorplatinate, - - | $6NH_3^{\frown}.Co_2.Cl_3+3PtCl_2+21HO.$ |
| " - - " " " " | $+6HO.$ |
| Chloraurate, - - | $6NH_3^{\frown}.Co_2.Cl_3+AuCl_3.$ |
| Cobaltidcyanid, - - | $6NH_3^{\frown}.Co_2.Cy_3+Co_2Cy_3+HO.$ |
| Sulphate, - - - | $6NH_3^{\frown}.Co_2.O_3, 3SO_3+5HO.$ |
| Nitrate, - - - - | $6NH_3^{\frown}.Co_2.O_3, 3NO_5.$ |
| Oxalate, - - - | $6NH_3^{\frown}.Co_2.O_3, 3C_2O_3+4HO.$ |
| Carbonate, - - - | $6NH_3^{\frown}.Co_2.O_3, 3CO_2+7HO.$ |
| Acid carbonate, - - | $6NH_3^{\frown}.Co_2.O_3, 3CO_2+HO, CO_2+5HO.$ |
| Chromate, - - - | $6NH_3^{\frown}.Co_2.O_3, 3Cr\ O_3+5HO.$ |

*Xanthocobalt.*

| | |
|---|---|
| Chlorid, - - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.Cl_2.$ |
| Chlorplatinate, - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.Cl_2+2PtCl_2+2HO.$ |
| Chloraurate, - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.Cl_2+AuCl_3+2HO.$ |
| Chlorhydrargyrate, - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.Cl_2+4HgCl+2HO.$ |
| Ferrocyanid, - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.Cy_2+FeCy+7HO.$ |
| Sulphate, - - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.O_2, 2SO_3+HO.$ |
| Nitrate, - - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.O_2, 2NO_5+HO.$ |
| Oxalate, - - - - | $NO_2^{\frown}.5NH_3^{\frown}.Co_2O.O_2, 2C_2O_3+5HO.$ |

In concluding* for the present an investigation to which we have devoted our leisure for several years, and which has been one of extraordinary difficulty, we desire to state our conviction that the subject is by no means exhausted, but that on the contrary there is scarcely a single point which will not amply repay a more extended study. The number of bases which the sesquioxyd of cobalt is capable of forming with ammonia is perhaps very large, and a careful study of the products of the decomposition of the salts of each base promises to yield an abundant harvest of interesting combinations. It is our hope to be able to return to the subject hereafter, and in a second part of our memoir to clear up some points which we have not as yet had time and opportunity fully to consider. In the mean time, we invite the attention of chemists to a class of salts which for beauty of form and color, and for abstract theoretical interest, are almost unequalled either among organic or inorganic compounds.

New York and Philadelphia, July, 1856.

---

## Art. IX.—*Fourth Supplement to Dana's Mineralogy;* by the Author.

The number of new species and new works in mineralogy which have been announced abroad since the date of the last Supplement is very small. We count up but three or four new names, one work on crystallography and another on artificial minerals, besides reviews and memoirs. Kenngott has issued his annual review "Uebersicht," etc. for the years 1854 and 1855, each a small quarto of 180 pages, posting up, in detail, whatever relates to the composition of rocks and mineral springs, as well as minerals. The annual published in Liebig's Jahresbericht for 1855, covering the same ground, has also appeared, having been prepared by Dr. Kopp.

In this country we have had some additions to the new names, and nearly all by Prof. C. U. Shepard. Professor Shepard has also issued the second (and concluding) part of his Treatise on Mineralogy, the first part of which appeared in 1852. Dr. Genth also has contributed an important paper to this Journal on American minerals.

The anhydrous silicates fall mainly [see Mineralogy] into two large groups, the *Augite* and *Garnet* sections—the former having

* I should do no justice to my own feelings if I did not in this place gratefully acknowledge the assistance which I have received in the analytical part of the labor from my friend and pupil, Mr. James R. Brant, whose zeal and skill have alone rendered it possible for me, amid the duties of a laborious professorship, to bring my own share of the work to a conclusion.—W. G.

the oxygen ratio between the bases and silica 1 : 2, the latter 1 : 1. The ratios 1 : 3 and 1 : 1½ characterize two other sections, but each comprises only two species, and in both, one of these has always been deemed doubtful. Leucophane has been the type species for the ratio 1 : 1½. But the recent analyses of this mineral and Melinophane (the latter now referred to Leucophane by Rammelsberg) show, that if the *fluorid of sodium* be reckoned as a base with the protoxyds (see beyond), the ratio of Melinophane becomes 1 : 1, which is the true Garnet ratio; and in Leucophane the discrepancy from this ratio is small, being less than in Iolite. It is probable therefore that the section characterized by the ratio 1 : 1½ will, on farther investigation, prove to be unrepresented.

Under the ratio 1 : 3, there are the species Mancinite and Edelforsite; the first is based on a badly made analysis, (as the account of it manifestly shows,) and is not known at the locality mentioned. The sooner it is struck from the science the better. The species Edelforsite appears to be well sustained by Hisinger's analyses, but requires a new examination.

## 1. *List of Works.*

Dr. J. Grailich (Vienna): Lehrbuch der Krystallographie von Professor W. H. Miller, translated and enlarged. 328 pp., 8vo, with an atlas in 4to of 19 copper plates. Wien, 1856.—Dr. Grailich is a profound writer on mathematics and in physics, especially optics, and has contributed much by his researches in optical mineralogy and crystallography to the progress of the science. This translation of Miller's Crystallography contains an important chapter on the optical characters of various mineral species and many laboratory products. Dr. Grailich also published in 1856 a paper entitled "Brechung und Reflexion der Lichts an zwillingsflächen optisch einaxiger vollkommen durchsichtiger Medien," a continuation of a paper on the same subject begun in 1855. We understand that he has in preparation a work on the physical characters of minerals.

Dr. A. Kenngott: Uebersicht der Resultate mineralogischer Forschungen im Jahre 1854, 180 pp., small 4to. Leipzig, 1856.—Ibid. im Jahre 1855, 180 pp., small 4to. Leipzig, 1856.

Liebig and Kopp's Jahresbericht, for 1855. Article "Mineralogie," pp. 903–985, and "Chemische Geologie," including meteorites, pp. 986–1029.

R. Hermann: Heteromeres Mineral-System, 213 pp. 4to, forming part of volume x, of the Nouv. Mém. de la Soc. Imp. des Naturalistes de Moscou.—A brief review of the species, classified in accordance with Hermann's views on Heteromerism. An undue prominence is given to crystallography, and in consequence, the groups often are not natural associations of species.

N. von Kokscharov: Materialen zur Mineralogie Russlands. St. Petersburg.—This fine work, illustrated with many beautiful plates of crystals has been received by us to page 304 of the second volume.

Quintino Sella (Turin): Studii sulla Mineralogia Sarda. 50 pp. 4to. Torino, 1856.—A paper on Twin Crystals of Calcite and some other species. Also by the same author, a very complete memoir "sulle Forme Cristalline dell' Argente Rosso," (Turin Academy of Science, Feb. 1856,) in which he reviews the crystalline forms of calcite and quartz, as well as red silver, giving the symbols of the planes according to different crystallographic systems.

CHARLES U. SHEPARD: A Treatise on Mineralogy. Third edition, Part II, pp. 241–452, completing the work. New Haven, 1857.—The work presents the latest results of Professor Shepard's mineralogical researches. It contains descriptions of the proposed species mentioned briefly in the "Report on the Canton Mine, Georgia," (see our last Supplement,) and adds other new species to those of that pamphlet—making in all for the past twelve months, twelve species—namely, *Xanthitane*, *Pyromelane*, *Pyroclasite*, *Glaubapatite*, *Epiglaubite*, *Cherokine*, *Hitchcockite*, *Harrisite*, *Glossecollite*, *Moronolite*, *Rastolyte*, *Nitrammite*. Besides these, the work contains the new names *Bismuthaurite* and *Parathorite* for minerals before partially described by him; and the following new names for species of yet unascertained existence, being known to occur only as a constituent in solutions, in *some* state of combination: viz., *Natrodine* (Iodid of sodium), *Natrobromite* (Bromid of sodium), *Luochalybite* (bicarbonate of iron), *Luocalcite* (bicarbonate of lime), *Luodiallogite* (bicarbonate of manganese), *Luomagnesite* (bicarbonate of magnesia); and also *Perlimonite* (hydrated oxyd of iron deposited from stagnant waters). In addition to these there are other new names made from chemical names by a system of compression,—*Carbacid* (from carbonic acid), *Carbhydrogen* (carburetted hydrogen), *Muriatacid* (muriatic acid), *Vitriolacid* (vitriolic acid), *Carbammonite* (carbonate of ammonia), *Phosphammonite* (phosphate of ammonia), *Salmiak* (sal-ammoniac), the German word being directly adopted.

The naming of salts in solution is anticipating, not other mineralogists simply, but nature. We do not know in what state of combination iodid of sodium may be, in a solution—whether alone or in a double salt,—or whether the same in all waters, mineral springs and brines,—or what the proportion of water present. The name cannot represent any particular species, being applied to what is unknown. It would seem soon enough to christen the thing after it had made its appearance. This remark applies to all the *Luo* species (which prefix, by the way, should be *Lyo*, as the Greek *u* is changed to *y* in English). *Perlimonite* is another case of forestalling investigation. No evidence is given that the material differs from described hydrates.

On page 396, allusion is made to the *Hydrophilite* and *Eisenchlorid* of Hausmann, as species that are met with *only in solution*. But referring to Hausmann's Mineralogy, we find the first mentioned as a deposit found sometimes with anhydrite and gypsum; and the latter as an earthy coating, and as having been observed by Hausmann himself in 1819 at Vesuvius as a volcanic sublimate along with sal-ammoniac. Scacchi notices the species in his late work.

Although we esteem Professor Shepard as a friend, and estimate highly his acuteness and energy in his favorite science, and his great success in developing the mineralogy of this country, in which he has had no equal, we still cannot hesitate to dissent from some of his views, and regret the haste with which he proposes new species. We cannot adopt the principle he avows on page 44 of this volume, especially as he exemplifies it. It is easy, on finding a mineral that looks unfamiliar, to make a few trials, and then cast it on the science with a name, to let it take its chance, hit or miss—the latter no (?) loss, the former all gain. But it is a wrong to the science. An imperfect blowpipe examination, or an analysis that is but a rude approximation, affords no satisfactory basis for a species. Moreover, stating the supposed composition in words, without giving the evidence from actual trials, is still less satisfactory; for such an assertion can have no weight: it is an intangible mode of presenting facts which does not belong to experimental science. When an author, after a chemical investigation, has published a species, consisting of pure titanic acid, as a *titanate of yttria*, and a year later, as *niobate of yttria and thorina*, it is his own fault if a cloud of doubt rests over what he may afterwards describe: and if other examples of error from time to time appear, the cloud must deepen, and prove an embarrassment and vexation at least to those who would inquire earnestly, as to his species. There is thus an injury to the science; and also, not less, to one who still deserves honorable mention for his mineralogical discoveries. It is not to be expected that the best mineralogist should generally be the best analyst. But where his own powers fail, he may obtain help of those who are able to give it.

We do not propose to criticise the work at large, either as to its crystallography, chemistry, or general descriptions. But there are some points connected mainly with American species, on which remark should be made. The numerous typographical errors in the work are much to be regretted.

*Lancasterite* is retained as a species, although shown to be identical with *hydromagnesite* by Smith and Brush. *Hydromagnesite* is placed as a subspecies under *Magnesite*, and no note is taken of its crystallization; while *Hydro-nickelmagnesite*, S., is numbered among good species, although very doubtful. *Williamsite*, S., is retained as a good species, and the more recent analyses, which show that it is serpentine, are not referred to. The same is true of *Picrolite* or *Chrysotile*. *Marmolite* is made a subspecies under *Kerolite*, and the later analyses which connect it with serpentine are not mentioned. *Dysyntribite*, S., also stands as a species, without a reference to the analyses of Smith and Brush, which prove it to be a rock; while *Pyrophyllite* (a silicate of alumina) is placed as a variety of *Talc*. *Vermiculite* is also added to talc, without a reference to Crossley's investigations.

*Nemalite* is separated from *Brucite*, of which it is a fibrous variety. *Jenkinsite*, S., stands as a good species, and *Antigorite* appears to be placed as a subspecies under it. No reference is made to Smith and Brush's analysis of the Jenkinsite, or to the analyses of Whitney and others of *Ozarkite*, S., which set aside his results. *Euphyllite* is arranged under Margarite, although the analyses of Smith and Brush show it to be distinct. *Unionite* is retained as a good species although shown by Smith and Brush to be *oligoclase*, the only intimation of a relation to oligoclase being given in the Index; and *Crocidolite* and *Carpholite* come in with a star (*) before the names, directly after Unionite, as if some way subordinate to that species. Under *Boltonite* no mention is made of the later analyses of that species by Smith which show a relation to Chrysolite. *Danburite* is published in the same way, giving the older wrong analysis, instead of the later by Smith and Brush. The American Oligoclase and its analyses are not alluded to.

The first part of the work, which treats of the species above mentioned, was published five years since, and this would be a sufficient apology for some of the omissions. But the title page for the whole work bears the date 1857, and there is, at the close, an Appendix, besides a supplementary one at the commencement, both recently printed, where we look in vain for the corrections that would bring the work down to the year 1857. We should not detail such omissions, were it not important that the facts with regard to American minerals should be fully presented. An American work should do better justice to American species and analysts.

On the species, in the second part, *Warwickite*, *Pyromelane*, *Parathorite*, *Bismuthaurite*, *Calyptolite*, *Chathamite*, *Glossecollite*, *Moronolite*, *Rastolyte*, and others, we offer some observations beyond. *Parophite*, made a species on p. 428, was described as a *rock* by Mr. Hunt. *Xanthitane* is without analysis and nothing is presented to show that it is anything more than a decomposing sphene; there is no evidence given that a *species* has resulted from the alteration. *Placodine* stands as a good species on p. 313, although shown to be a furnace product in Pogg., lxxxiv, 585, and lxxxv, 46.

Dr. D. D. Owen: Report of the Geological Survey in Kentucky, made during the years 1854 and 1855, R. Peter, Chemical Assistant, S. S. Lyon, Topographical Assistant. 416 pp. 8vo, with many plates and maps.

Oscar M. Lieber: Report on the Geological Survey of South Carolina, being the first Annual Report. 136 pp. 8vo, with many maps and plates.

Dr. Adolph Gurlt: Der pyrogenneten künstlichen Mineralien, namentlich der krystallisirten Hüttenerzeugnisse. 100 pp. 8vo. Freiberg, 1857.—A work reviewing what is known on the artificial formation of minerals.

## 2. *Crystallization, Formation of Minerals, etc.*

E. Pasteur: On the modes of increase in Crystals and the causes of variation of secondary forms. Ann. d. Ch. et de Physique, [3], xlix, p. 5, Jan. 1857.

F. von Kobell: Observations with the Stauroscope and on Pleochroism. J. f. pr. Chem., lxv, 321, lxix, 217.

T. Scheerer: Polymerous Isomorphism. J. f. pr. Chem., lxviii, 319.

———: On Pseudomorphs ("After-Krystalle"). 41 pp. 8vo. Braunschweig, in Lieb. Pogg. u. Wöhler's Handwörterbuch, 2te Aufl.

F. Kuhlman: Formation of minerals by the wet way. Compt. Rend., xlii, 374.

A. GAUDIN: Artificial formation of Sapphires. L'Institut, No. 1212.

J. W. MALLET: Oxyd of zinc, a furnace product at an iron-furnace in Benton Co. Alabama. Am. J. Sci., xxiii, 184.

## 3. *Descriptions of Species.*

ÆSCHYNITE [p. 357, and Suppl. II].—Analysis by Hermann (J. f. pr. Chem., lxviii, 97): C̈b 21·69, C̈b 11·51, T̈i 25·90, C̈e 22·20, Ċe 5·12, L̇a 6·22, Ẏ 1·28, Ḟe 5·45, ign. 1·20=100·57.

ALLANITE [p. 208, and I, II, III].—The orthite occurring in syenite near Weinheim, has been analyzed by F. Stifft (Leonh. u. Bronn, 1856, 395), with the following results:

| | S̈i | Ä̈l | Ḟe | Ċe, L̇a | Ṁn | Ẏ | Ċa | Ṁg | Ṅa | K̇ | Ḣ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 32·79 | 14·67 | 14·71 | 22·31 | *tr.* | 2·42 | 9·68 | 1·20 | 0·34 | 0·41 | 2·67=101·20 |
| 2. | 35·08 | 14·70 | 15·81 | 18·91 | *tr.* | 1·47 | 9·45 | 1·19 | 0·34 | 0·40 | 2·67=100·02 |

Oxygen ratio for Ṙ, R̈, S̈i, in 1, 10·04 : 7·05 : 17·49; in 2, 9·63 : 7·07 : 18·71. [In each, the oxygen of the silica equals quite nearly that of all the bases, coming under the general garnet formula (Ṙ³, R̈)S̈i, characteristic of allanite, epidote, garnet, etc. —D.] Color pitch-black, brownish-black; streak greenish-gray. G.=3·44—3·47. BB. fuses with intumescence to a brownish-black mass.

ALLOPHANE [p. 336, and I, II].—Occurs in the fissures of the chalk near Woolwich, England. J. Morris, Phil. Mag. [4], xiii, 76. See farther Addenda to this Supplement.

ANALCIME [p. 318].—Crystals from trachyte in the Kaiserstuhl, afforded Dr. Weltzien (Ann. Ch. Pharm., xcix, 287):

| S̈i | Ä̈l | F̈e | Ṁg | Ċa | Ṅa | K̇ | Ḣ | P̈ |
|---|---|---|---|---|---|---|---|---|
| 54·02 | 22·54 | 1·35 | 0·57 | 2·91 | 10·14 | 0·71 | 8·93 | *trace* =101·17 |

giving the usual formula.

ANNIVITE, *Brauns.*—A mineral like tetrahedrite in external and blowpipe character, and probably, according to Kenngott, an impure variety. It occurs mixed with chalcopyrite in the Annivier valley, and near tetrahedrite. Analysis gave Brauns (Mitth. nat. Ges. Bern, 1854, in Kenngott, Min. Forsch. for 1855):

| S | Sb | As | Bi | Cu | Fe | Zn | Quartz |
|---|---|---|---|---|---|---|---|
| 23·755 | 8·800 | 10·962 | 4·943 | 35·566 | 3·850 | 2·006 | 9·400 = 100·282 |

APATITE [p. 396, and I, II, III].—Apatite occurs in the Jura limestone near Amberg, in nodular and stalactitic masses, with a columnar texture and a yellowish-white color. It contains a trace of iodine.—W. Mayer in Ann. d. Ch. u. Pharm., ci, 281.

*Coprolites.*—Composition of Coprolites in the Rothliegenden (Permian) of north Bohemia, occurring in a bituminous slate, at Oberlangenau near Starkenbach, according to A. E. Reuss (Sitz. Wien, 1856, xviii, 124).—The unorganic part (25·97 p. c.) afforded Rochleder, in Reuss's laboratory, Phosphoric acid 24·43, carbonic acid 13·29, lime 49·70, magnesia 5·03, chlorid of sodium 7·55 = 100. 9·9 p. c. of the lime are supposed to be united to the organic material, 17·2, with the carbonic acid, and 22·5 with the phosphoric acid, the rest of this acid being united with the 5 p. c. of magnesia. It is remarkable that 74·03 per cent of the whole coprolite is organic. The following table gives a comparative view of the composition of different coprolites.

| | 1. Burdiehouse. | 2. Fifeshire. | 3. Burdiehouse. | 4. Burdiehouse. | 5. Koschtitz. | 6. Oberlangenau. |
|---|---|---|---|---|---|---|
| Phosphate of lime, | 9·58 | 63·60 | 85·08 | 83·31 | 50·89 | 15·25 |
| Carbonate of lime, | 61·00 | 24·25 | 10·78 | 15·11 | 32·22 | 4·57 |
| Carbonate of magnesia, | 13·57 | 2·89 | —— | —— | —— | 2·75 |
| Sesquioxyd of iron, | 6·40 | *trace* | —— | —— | 2·08 | —— |
| Alumina, | —— | —— | —— | —— | 6·42 | —— |
| Silica, | 4·13 | *trace* | 0·34 | 0·29 | 0·14 | —— |
| Organic material, | | 3·38 | 3·95 | 1·47 | 7·38 | 74·03 |
| Water, | 5·33 | 3·33 | —— | —— | —— | —— |
| Lime of organic part, | —— | —— | —— | —— | —— | 1·44 |
| Chlorid of sodium, | —— | —— | —— | —— | —— | 1·96 |
| | 100·01 | 97·45 | 100·15 | 100·18 | 99·03 | 100·00 |

Nos. 1 and 2 by Gregory and Walker, 3 and 4 by Connell, 5 by Quadrat, 6 by Rochleder.

*Phosphatic nodules.*—A phosphatic nodule in the brown coal beds near Roth, where are found also remains of plants and fish, afforded the following on analysis by Mr. Hassencamp (Leonh. u. Bronn, 1856, 422): Phosphate of lime 45·575, phosphate of magnesia 2·042, phosphate of iron 27·708, magnesia 1·339, lime 4·200, alumina 0 625, organic acid 3·334, water 7·500, carbonic acid and loss 7·677 = 100. Color externally pitch-black, within honey-yellow inclining to pitch-black. G.=2·313. H.=2·5.

Aragonite [p. 448, and II. III].—Leydolt has examined the structure of aragonite twins by polarized light, and published a series of plates of great beauty illustrating the subject (Sitzungsb. Wien, xix, 10, Jan. 1856). In some compound crystals, consisting mainly of two crystals, a third is detected in spots or lines through the interior; and the component crystals in other cases are very strangely interpenetrated by one another. He also shows that in the spines of an Echinus and most shells not pearly, the carbonate of lime is calcite; but when the interior is pearly, this part is aragonite and the outer calcite. In Meleagrina the shell is mostly aragonite.

Astrakanite? [p. 379].—To this place we refer, with a query, a crystallized salt obtained from the soil near Mendoza, South America, by N. H. Bishop, and analyzed by Dr. A. A. Hayes (Proc. Boston Soc. N. H., v, 391, 392). It occurs over the dry country from San Luis de la Punta to the foot of the Andes at a depth of from a few inches to two feet; and is especially abundant east of the town of San Juan. It is met with in crystals of indistinct form at the junction of two layers of salt. Hardness above that of calcite. Soluble without residue in water, affording a solution which on evaporation at 150° F. leaves the salt with some of the original physical characters. Heated loses water readily: at a red heat fuses quietly to a transparent anhydrous liquid, and on cooling, there remains an opaque white crystalline solid. Attracts moisture in the climate of Boston. Composition varying; one sample afforded Dr. Hayes:

$\ddot{S}$ 49·658 $\dot{N}a$ 23·758 $\dot{M}g$ 9·904 Cl 0·260 $\dot{H}$ 16·420 = 100.

This corresponds to 2 of sulphate of magnesia and 3 of sulphate of soda ($\dot{M}g\ddot{S}$ 29·712, $\dot{N}a\ddot{S}$ 52·984), with $7\frac{1}{2}$ of water, and affords the general formula $(\dot{M}g, \dot{N}a)\ddot{S}+1\frac{1}{2}\dot{H}$; while astrakanite corresponds to $(\dot{M}g, \dot{N}a)\ddot{S}+2\dot{H}$, and $\dot{M}g$ and $\dot{N}a$ are in equal proportions. Other analyses gave Dr. Hayes more nearly this result, as follows:

| $\dot{N}a\ddot{S}$ | $\dot{M}g\ddot{S}$ | $\dot{H}$ | NaCl | Crenate $\dot{C}a$ & $\dot{F}e$, $\ddot{S}i$ | Sand |
|---|---|---|---|---|---|
| 48·00 | 34·20 | 16·42 | 1·21 | 0·17 | —— = 100 |
| 45·82 | 33·19 | 18·84 | 1·79 | 0·30 | 0·06 = 100 |
| 45·74 | 33·31 | 19·60 | 1·16 | 0·13 | 0·06 = 100 |

Dried at 90° F. the amount of water was but 15·20 per cent, from which Dr. Hayes infers that the species may contain normally but $1\dot{H}$ instead of $2\dot{H}$.

Beryl [p. 178, and II].—Dr. Heddle confirms (Phil. Mag., [4], xii, 386) the conclusion that the *Davidsonite* of Thomson is nothing but beryl.

BISMUTHAURITE, *Shepard* (Shep. Min., 3d edit., 304).—In particles weighing less than a grain; somewhat malleable, like palladium in color. H.=2·5—3. G.= 12·44—12·9. Structure hackly or subfibrous. With nitric or hydrochloric acid a slight reaction, but with the two united slowly dissolves excepting traces of a heavy white precipitate. BB. fuses as soon as touched by the flame, giving off white fumes coloring the support bright yellow as long as it is hot, becoming white when cold; the globule crystalline on cooling. By continuing the heat, globule reduced half in bulk and comes out pure gold. [Locality not mentioned, but given in Amer. Jour. Sci., [2], iv, 281, as the North Carolina gold region. It is also added in that place that there was a suspicion that the grains were "only a product of the miner's process of separating his gold by means of amalgamation, instead of being a true mineral production." The author described it in the Jour. Sci. *in a note* on this account: and he appears still to recognize the suspicious character of the species, as he has put it in fine type in this new edition of his Mineralogy.—D.]

Bismuthine [p. 33, 503, and I].—The Riddarhyttan bismuthine afforded Dr. F. A. Genth (Am. J. Sci. [2], xxiii, 415):

| S | Te, and Se *trace* | Bi | Cu | Fe | Actinolite. |
|---|---|---|---|---|---|
| 18·19 | 0·30 | 77·33 | 0·39 | 0·31 | 2·93 = 99·45 |

Deducting 1·12 as chalcopyrite, with the actinolite, the percentage becomes, S 18·65, Te 0·32, Bi 81·03 = (Bi, Te)$S^3$.

Bismutite [p. 462].—Analyses of the bismutite of Brewer's Mine, Chesterfield District, S. Carolina, by Dr. F. A. Genth, Am. J. Sci. [2], xxiii, 426. The results show, like those of Rammelsberg, that the mineral is an impure hydrous basic carbonate of bismuth. Bismutite occurs, according to Dr. Genth, in Gaston Co., N. C., along with native gold, in yellowish-white concretions, pulverulent, but sometimes showing a crystalline structure.

Bleiniere (Antimony ochre) [p. 142].—Bleiniere has been found, according to H. J. Brooke (Phil. Mag. [4], xii, 126), in Cornwall, where it has resulted from the decomposition of Jamesonite. The composition varies much. Mr. Dick obtained in an analysis, Oxyd of lead (Ṗb) 40·73, antimonic acid (S̈b) 47·36, water (Ḣ) 11·91. Dr. Heddle found, Oxyd of lead 46·68, antimonous acid 42·44, water 11·98; and from a brown variety, Oxyd of lead 43·94, antimonous acid with antimonic ochre 46·70, water 6·625.

Brookite [p. 123, and II].—Fine crystals of iron-black color occur in the Grieser Valley. D. F. Wiser, Leonh. u. Bronn, 1856, 168.—Kokscharov figures crystals of Brookite from the Ural in his Min. Russl., ii, 273.

Breithauptite [p. 53].—Stated to occur at the Chatham (Ct.) Mine in Shep. Min., p. 320.

Calcite [p. 435, 503, and I, II, III].—Q. Sella gives a table of the crystalline forms of calcite in a paper "dell'Argento Rosso," (Accad. Sci. Torino, 1856,) and mentions the following planes not given in the Mineralogy. The rhombohedrons $\frac{3}{10}$, 6, (observed in Traversella crystals), 7, 28, −14.—Prisms (omitted in Min.) $i\frac{4}{3}$, $i\frac{3}{2}$, $i2$, $i$.—Scalenohedrons $\frac{1}{3}^{\frac{7}{3}}$ (Andreasberg crystal), $\frac{2}{3}^{\frac{4}{3}}$ (ib.), $1^{\frac{4}{3}}$, $1^{\frac{11}{3}}$, $1^4$, $1^{15}$, $-\frac{7}{5}^{\frac{9}{7}}$. $-\frac{3}{2}^{\frac{7}{3}}$ $-\frac{4}{5}^{\frac{5}{2}}$ $-\frac{8}{7}^{\frac{9}{4}}$ $\frac{8}{3}2$ $-\frac{1}{5}^{13}$ $\frac{1}{3}^{23}$ (Andreasberg), $-\frac{7}{5}^{\frac{11}{7}}$ (Traversella), $-1^{\frac{9}{5}}$ (Traversella), $-\frac{1}{4}^{\frac{71}{3}}$ $-161^{\frac{25}{23}}$ $-\frac{5}{4}^{\frac{13}{9}}$ $-\frac{154}{3}^{\frac{35}{33}}$.—Twin faces $O$, $-\frac{1}{2}$, $\frac{1}{2}$, $R$, $-2$, $i2$.—Analyses of limestones in Kentucky by R. Peter, in Rep. Geol. Ky., 1856.

Calyptolite [p. 195].—This species is stated in Shepard's Min., 3d edit., p. 288, to be probably altered zircon.

CANTONITE, *Pratt.*—Announced as a new species by N. A. Pratt, in this Journal, [2], xxii, 449, and xxiii, 409. It has the external characters and composition of covelline, excepting a cubical cleavage, and if a good species, this sulphuret (CuS) is dimorphous. Mr. Pratt obtained in an analysis, Sulphur 33·490, copper 66·205, impurities 0·305 = 100. H.=1·5—2. G.=4·18.

Dr. Genth (this Jour., xxiii, 417) considers the Cantonite a pseudomorph after the Harrisite, and through this, after galena. His analyses obtained:

| S | Se | Ag | Cu | Pb | Fe | insoluble |
|---|---|---|---|---|---|---|
| 32·765 | *trace* | 0·355 | 65 604 | 0·107 | 0·251 | 0·157 = 99·239 |

Chalcodite [p. 500].—Analysis by J. W. Mallet (Shep. Min., 3d edit., p. iii); S̈i 39·77, Ḟe 40·84, M̈n *trace*, Ä1 8·52, Ċa 5·98, Ṁg 1·97, Ḣ 5·51 = 102·59. Part of the lime is supposed to be carbonate; and probably a small portion of the iron was sesquioxyd. [Dr. Mallet, in a letter to the writer, states that the results of his analysis are doubtful, "and can hardly be depended on for even a probable formula," as he had too little of the mineral for a satisfactory investigation.—D.]

CHALYBITE [p. 444, and III].—The massive clayey spathic iron, known as the Baltimore ore, occurs in nodules in a bed of white clay underlying the tertiary on the west side of Chesapeake Bay and extends along for fifty miles.—C. E. Smith, Proceedings Acad. Nat. Sci., Philad., viii, 102.

Earthy chalybite occurs with the coal measures of Kentucky, especially in the lower coal measures. Sp. gr. varies from 3·135 to 3·65. Owen's Rep. Geol. Kentucky, 1856.

CHATHAMITE [p. 56, 512].—Shepard, in his 3d edition, p. 311, keeps his so-called Chathamite separate from chloanthite, and arranges gersdorffite, quite another species, between them. [According to the analyses, it is only a chloanthite with 12 or 13 per cent of iron. Some Schneeberg chloanthite contains 6 to 7 p. c. of iron.—D.]

CHEROKINE [Suppl. III.]—Is chiefly phosphate of lead, according to Prof. Shepard (Shep. Min. p. 407 and Am. J. Sci. xxiv, 38), in addition to the phosphate of alumina and zinc, mentioned in Suppl. III. [This confirms our reference of the species to pyromorphite, of which it appears to be an impure variety.—D.] Color white, pinkish within, often greenish or bluish without. Lustre adamantine. Form hexagonal with low pyramidal summits. H. = 3·75. G. = 4·81.—See also Genth, this Jour., xxiii, 422.

CHLORITE [p. 294, 296.]—The Pennine of Zermatt and Valais, according to M. Descloizeaux (L'Institut, No. 1207), is mostly *negative*, optically, whilst that of Ala in Piedmont is *positive*, or without action on polarized light. On optical grounds, Descloizeaux unites the leuchtenbergite and white chlorite of Mauleon with the *positive* pennine. While with the type of clinochlore, he would unite on the same ground, the hexagonal chlorite of Achmatowsk, Ala, Traversella, Tyrol and Taberg. He holds also that the ripidolites, very rich in oxyd of iron, should constitute a group apart, comprising the ripidolite with contorted plates of St. Gothard and the Grisons, and the scaly chlorite disseminated in abundance in the granites of the Alps.

C. Heusser has examined the pennine of Zermatt with polarized light, but without observing any colored rings or the black cross, so apparent in rhombohedral crystals. (Pogg. xcix, 174).

A green *chlorite-like* micaceous mineral occurring with the margarite of the Tyrol, proves on analysis by Hetzer, to contain (Kenng. 1855, 48):

| $\ddot{S}i$ | $\ddot{A}l$ | $\ddot{F}e$ | $\dot{M}g$ | $\dot{C}a$ | F | $\dot{H}$ |
|---|---|---|---|---|---|---|
| 28·04 | 23·94 | 25·50 | 15·74 | 1·69 | 0·98 | 2·30 = 98·19 |
| | 22·43 | 25 91 | 15·61 | 1·17 | | |

Besides, there is some alkali. Heintz, who describes the mineral, states that the composition requires farther investigation, as the analysis affords no good formula. [The *Corundophilite* of Shepard may be identical with this mineral.—J. D. D.]

CHLORID OF IRON.—Scacchi mentions the chlorid of iron, $Fe^2Cl^3$, as among the products of the recent eruption of Vesuvius (Eruz. Vesuv. 1850–1855); and attributes the yellow color of the lavas about the fumaroles partly to this species. Hausmann noticed the species at the same crater in 1819, and describes it as an incrustation of a brownish-red color, light or dark, easily soluble in water and alcohol, and vaporizable before the blowpipe.

The existence of the *protochlorid* of iron at Vesuvius was announced by Monticelli and Covelli; but Scacchi did not obtain any sure evidence of its existence there in his researches.

CHRYSOLITE [p. 184, and I, II, III.]—The iron in the analysis by Damour cited in the 3d Suppl. should be protoxyd and the water 1·75. Damour's paper is published in the Ann. des Mines, [5], viii, 90. A second analysis afforded, $\ddot{S}i$ 36·87, titanic acid 3·51, $\dot{M}g$ 50·14, $\dot{F}e$ 6 21, $\dot{M}n$ 0·60, $\dot{H}$ 1·71 = 99·04. The color is brownish red, and the powder orange-yellow. G. = 3·250. B.B. infusible.

CINNABAR [p. 48, and II].—The Idria quicksilver mine is situated in the Carboniferous formation. It is distributed through the beds and not in veins, as if it had been of aqueous origin rather than igneous. L'Institut, No. 1204.

CLAY.—A porcelain clay from Jacksonville, Ga., afforded J. W. Mallet (this Jour. xxiii, 183):

| Comb'd $\ddot{S}i$ | Free $\ddot{S}i$ | $\ddot{A}l$ | $\ddot{F}e$ | $\dot{C}a$, $\dot{K}$, etc. | $\dot{H}$ | undecomp. |
|---|---|---|---|---|---|---|
| 39·75 | 4·85 | 38·92 | 0·78 | 1·03 | 13·38 | 0·90 = 99·61 |

It corresponds nearly to the formula $\ddot{A}l\,\ddot{S}i + 2\dot{H}$.

COAL [p. 26 and II].—Many analyses in Owen's Rep. Geol. Kentucky, 1856.

COLUMBITE [p. 353 and II].—The columbite crystals of the greenland cryolite locality have been measured with the following results by Descloizeaux (Ann. des Mines, [5], viii, 389). Observed planes: $O$, $^1\breve{1}$, $\frac{1}{3}\breve{1}$, $\frac{2}{3}\breve{1}$, $i\breve{1}$, 1, $I$, 1-$\frac{\breve{3}}{2}$, 2-$\frac{\breve{3}}{2}$, 2-$\breve{2}$, 1-$\breve{3}$, 2-$\breve{3}$, 9-$\breve{3}$, $i\breve{3}$, 2-$\breve{6}$, $1\breve{\imath}$, $2\breve{\imath}$, $i\breve{\imath}$; $I : I = 100° 40'$, $O : \frac{1}{3}\breve{1} = 160° 34'$ (observed 160° 30'), $i\breve{1} : I = 140° 20'$ (observed 140° 0'), 1-$\breve{3}$ : 1-$\breve{3}$ (over brachyd. edge) 150° 18′ (observed 150° 30′.

Hermann announces (J. f. pr. Chem., lxviii, 65) that the Bavarian columbite contains *tantalic* acid (31·17 p. c.) along with columbic acid. He obtained for the atomic weight of columbium 664·1. Ilmenium, he now merges in columbium, regarding ilmenic acid as a compound of two columbium acids, or $\ddot{C}b\,\ddot{C}b$. The columbite of Middletown afforded him, Tungstic acid 0·26, $\ddot{C}b$ 64·43, $\ddot{C}b$ 13·79, $\ddot{S}n$ 0·40, $\dot{F}e$ 14·06, $\dot{M}n$ 5·63, $\dot{M}g$ 0·49 = 99·06.

According to Oesten (Pogg. xc, 617), the columbite of Bavaria does *not* contain tantalic acid.

The columbite of Middletown, Ct., has been analyzed by C. F. Chandler (Inaug. Dissert.), with the following result (mean of two analyses):

$\ddot{C}b$ 76·69 $\ddot{S}n$ 0·60 $\dot{F}e$ 18·23 $\dot{M}n$ 3·14 $\dot{C}a$ 0·48=99·24

giving the simple formula $\dot{R}\,\ddot{C}b$. G. = 5·583, in coarse powder 5·593. For the Bodenmais columbite he obtained (ibid.):

$\ddot{C}b$ 75·02 $\ddot{S}n$ 0·47 $\ddot{W}$ 0·39 $\dot{F}e$ 17·22 $\dot{M}n$ 3·59 $\dot{C}a$ 0·22 = 96·91. G.=5·971

COPIAPITE [p. 388 and I, III.]—Kenngott (Min. Forsch. 1855) unites the *stypticite* and *fibroferrite*, under the oxygen ratio for $\ddot{F}e$, $\ddot{S}$, $\dot{H}$, of 3 : 6 : 11=$\ddot{F}e\,\ddot{S}_2 + 11\dot{H}$, which includes the copiapite analyzed by J. L. Smith (Suppl. I).

*Misy* [p. 389], according to analyses by Borcher, and Ahrend and Ulrich (in Hartmann's Zeit. 1854, cited in Kenngott's Min. Forsch. for 1854) has the same composition, observes Kenngott, with the true copiapite analyzed by Rose. Borcher's specimens were pale yellow or citron-yellow, a loose aggregate of crystalline scales, from near Goslar. G.=2·14. H.=1·5.

| | $\ddot{S}$ | $\ddot{F}e$ | $\dot{Z}$ | $\dot{M}$ | $\dot{H}$ |
|---|---|---|---|---|---|
| 1. Borcher, crystallized, | 38·00 | 24·24 | 5·80 | —— | 30·06 = 98·10 |
| 2. Ahrend and U., cryst'd. | 39·44 | 28·00 | 2·00 | —— | 30·64 = 100·08 |
| 3. " " earthy, | 38·07 | 26·03 | 2·36 | 1·26 | 30·50 = 98·22 |

They correspond to the formula $\ddot{F}e^2\,\ddot{S}^5 + 18\dot{H}$.

COPPER [p. 17 and II].—The native argentiferous copper of Lake Superior has been found by Mr. Hautefeuille to contain mercury. He found in an analysis, Copper 69·280, silver 5·453, mercury 0·019, gangue 25·248. 138·56 kilograms of copper gave him 10·906 of silver, 0·038 of mercury, with 50·496 of the gangue. Comptes Rend., 1856, July, p. 166.

Native copper in hexagonal prisms, pseudomorphous after aragonite, are described by A. Kenngott in Pogg. c, 467.

CRYOLITE [p. 97, and II, III.]—von Kobell, from his researches with the stauroscope, has concluded that cryolite is dimetric.—J. f. pr. Chem., lxv, 328.

DANBURITE [p. 212, and I, II.]—Kenngott points out a close relation between the formulas of danburite and anorthite. Writing for boracic acid $B^2O^3$, the analogy is perfect; at the same time both are triclinic.

DATHOLITE [p. 334, and I, II, III.]—Senarmont states (Ann. des Mines, [5], viii, 497) that when crystals are sliced precisely parallel to the terminal plane $O$. and examined by polarized light, the colors spread most on one side instead of being uniform around, showing that beyond doubt the prism is *oblique* and not a right prism.

DEMIDOFFITE, *N. Nordenskiöld*, Bull. Soc. Imp. Nat. Moscou, 1856, No. 1, p. 128.—This mineral, from Tagilsk in the Ural, is an amorphous species, related to chrysocolla and has gone by the name of blue malachite. It occurs in mammillated crusts, and sometimes the layers alternate with malachite and tagilite or other phosphates. Color sky-blue, sometimes a little greenish. Streak white. H.=2 nearly. G.=2·25. Fracture a little waxy. Transparent only on the edges, but more so on being put in water. Porous and adhering to the tongue. B.B. becomes black, and in the inner flame melts easily, giving a black scoria with a metallic lustre externally. In a glass tube yields water with no acid reaction. With borax fuses in the outer flame easily without intumescence, affording a glass at first black and then bluish green on cooling; in the inner flame the pearl is nearly colorless. Each time on commencing to re-heat the bead, the flame appears greenish. With salt of phosphorus a skeleton of silica. Composition:

| | S̈i | Ä̇l | Ċu | Ṁg | Ḣ | P̈ | |
|---|---|---|---|---|---|---|---|
| | 31·55 | 0·53 | 33·14 | 3·15 | 23·03 | [10·22] | =100 |
| Oxygen | 16·39 | 0·25 | 6·67 | 0·60 | 20·47 | 5·73 | |

The rocks at Tagilsk are decomposed along the veins to a great depth. Even to a depth of 500 feet, to which the copper mines descend, the rocks are all disintegrated excepting the limestone about the ore. A large isolated block of malachite was laid bare in 1848 at a depth of 315 feet. Sometimes the masses of malachite have within a mass of native copper, surrounded with red copper and malachite and sometimes with Demidoffite, Tagilite, and phosphochalcite. The sulphurets increase in proportion as they descend in the mine.

DECHENITE [p. 361].—Fischer and Nessler have described (Leonh. u. Bronn's Jahrb., 1855, 570), a supposed new vanadate of lead under the name of *Eusynchite*, which contains, according to their analysis,—

V̈ 22·69 V̈ 20·49 Ṗb 55·70 S̈i 0·94 loss 0·18 = 100

affording the formula Ṗb V̈+Ṗb V̈. It is from Freiburg in Brisgau, where it is found in nodular and stalactitic forms. H.=3·5. G.=4·945. Color yellowish red, leather-yellow; streak paler. B.B. fuses to a lead-gray globule and yields lead. Easily soluble in nitric acid. Kenngott observes (Min. Forsch. for 1855) that supposing the acid to be all vanadic, the formula is that of Dechenite, which it much resembles.

The following note on *Arœoxene*, *Dechenite* and *Eusynchite* has been communicated for this Supplement by Prof. George J. Brush.

*Note by G. J. Brush.*—Dr. Krantz of Bonn informed me in the summer of 1856 that v. Kobell's Arœoxene is identical with Dechenite—that it is in fact the same mineral from the same locality.

Von Kobell in his description of Arœoxene mentions it as occurring at Dahn in the Palatinate, while Krantz gave the locality of Dechenite as Lauter Valley near Nieder-Schlettenbach. The small village of Dahn is in Lauter Valley near Nieder-Schlettenbach, so that there is really no difference as to locality. The physical properties of arœoxene and dechenite, as described by von Kobell and Bergemann, are identical. The analysis of dechenite by Bergemann gives its composition as a simple vanadate of lead Ṗb V̈; but v. Kobell's analysis of arœoxene gives, besides lead and vanadic acid, 16·32 pr. ct. of oxyd of zinc. An authentic specimen of dechenite obtained from Dr. Krantz, which I have examined, contained a considerable amount of zinc, so that there can be little doubt as to the propriety of uniting the two minerals.

The new species *Eusynchite* bears so strong a resemblance to dechenite that I was led to make a qualitative examination to see whether it might not also contain zinc. My analysis proved the presence of zinc, but the small amount of mineral at command was not sufficient for a qnantitative determination. It is much to be desired that some analyst having more of the mineral should make a special examination in regard to this point.

DIAMOND [p. 24 and I].—For some years, says Descloizeaux (Ann. des Mines, [5], viii, 304), a variety of black diamond has come from a region of arenaceous rocks near Bahia in Brazil, which has been known among lapidaries as *carbonate*. It is essentially crystalline, sometimes in small octahedrons, sometimes massive, compact or cellular. Specimens as large as a nut have rounded edges, resinous lustre, and a

brownish black, greenish gray, or ash-gray color; and are evidently worn crystals, one of them showing the form of a cube. The mineral most commonly found among the imported black diamonds or *carbonate*, are tourmaline, zircon, garnet, brown staurotide, rutile, and a black ore of tantalum. Occasionally grains of gold occur in the *carbonate*, showing that the age of the material is that of the gold rocks.

Observations on the Koh-i-Noor, Amer. J. Sci. [2], xxii, 278.

Dolomite [p. 441, and I, II].—Twins in the dolomite crystals of Traversella are figured by Q. Sella in Studii sulla Min. Sarda, Turin, 1856.

Dufrenite [p. 427].—According to Dr. F. A. Genth (Am. J. Sci. [2], xxiii, 423), dufrenite occurs as a fibrous coating, $\frac{1}{8}$th to $\frac{1}{2}$ in. thick, in the greensand formation at Allentown, New Jersey. Color dark leek-green; changing to brown as it passes to limonite. Analysis of the green part by C. A. Kurlbaum, Jr.:

$\dddot{P}$ 32·61 $\ddot{F}e$ 53·74 $\dot{F}e$ 3·77 $\dot{H}$ 10·49 $\ddot{S}i$ 0·72 = 100·95

Oxygen ratio for $\ddot{R}, \ddot{R}, \dddot{P}, \dot{H}$, 0·84 : 16·10 : 18·28 : 9·32. Dr. Genth regards the mineral as containing, through its alteration, some vivianite, and as having the formula $\ddot{F}e^3\,\dddot{P}^2 + 4\dot{H}$.

Dufrenoysite [p. 77 and I, II, III].—This is the gray prismatic sulpho-arseniuret from the valley of Binnen. Crystalline form, according to Descloizeaux (Ann. des Mines, viii, 389), trimetric. One fine crystal 33 mm. long, 12 broad, and 7 thick; others smaller. Cleavage brachydiagonal distinct and rather easy; also basal distinct; also parallel to $2\breve{i}$. $I : I = 118° 1'$; $O : 1\breve{i} = 149° 1'$ for other brachydomes, $O : \frac{1}{7}\breve{i} = 175° 8'$, $O : \frac{1}{5}\breve{i} = 173° 12'$, $O : \frac{1}{4}\breve{i} = 171° 31'$, $O : \frac{1}{3}\breve{i} = 168° 45'$, $O : \frac{1}{2}\breve{i} = 163° 20'$, $O : \frac{3}{4}\breve{i} = 155° 24'$, $O : 2\breve{i} = 129° 58'$, $O : \frac{5}{2}\breve{i} = 123° 50'$; macrodomes, $O : \frac{1}{2}\bar{i} = 153° 35'$, $O : \frac{5}{14}\bar{i} = 160° 28'$, $O : \frac{5}{12}\bar{i} = 157° 31'$, $O : \frac{5}{8}\bar{i} = 148° 10'$, $O : \frac{5}{4}\bar{i} = 128° 51'$, $O : \frac{5}{2}\bar{i} = 111° 56'$. Other planes observed, $i\breve{i}$, $i\bar{i}$, $\frac{5}{6}\bar{i}$, $\frac{5}{3}\bar{i}$, $\frac{8}{15}\breve{i}$, $\frac{7}{8}\breve{i}$, $\frac{7}{5}\breve{i}$, $\frac{8}{5}\breve{i}$, $\frac{7}{4}\breve{i}$, $\frac{11}{6}\breve{i}$, $\frac{11}{4}\breve{i}$, $\frac{13}{4}\breve{i}$, $\frac{15}{2}\breve{i}$. $O : \frac{1}{2} = 149° 55'$, $O : \frac{5}{12} = 154° 14'$, $O : \frac{5}{16} = 160° 6'$, $O : \frac{5}{8} = 144° 5'$, $O : \frac{7}{8} = 134° 36'$, $O : \frac{7}{6} = 126° 29'$, $O : \frac{7}{4} = 116° 15'$, $O : \frac{7}{2} = 103° 51'$, $O : 4 = 102° 10'$. Descloizeaux also mentions some planes situated obliquely on the angles, whose exact position has not been ascertained.

The prismatic crystals are sometimes penetrated by dodecahedrons, which according to the analyses of M. Uhrlaub pertain to a variety of tennantite, and it is possible that the mineral analyzed by Damour has some traces of mixture.

Descloizeaux objects to substituting the name *Binnite* for the prismatic crystals (v. Waltershausen's *scleroclase*), and using *Dufrenoysite* for the monometric sulpho-arseniuret of copper, as suggested by M. Heusser, as it would only make confusion. He remarks that the name *Binnite* might better be given to the monometric tennantite-like mineral.

Eisennickelkies of Scheerer [p. 42].—Named *Nicopyrite* by Shepard in his Min., 3d edit. 1856, p. 307.

Enargite [p. 87, 506].—An ore of an iron-gray color and trimetric in crystallization, occurring in small grains or imperfect crystals in a compact quartz rock in Chesterfield District, S. C., at Brewer's Mine, is referred with a query to enargite by Dr. F. A. Genth (this Jour., [2], xxiii, 420).—An imperfect analysis afforded:

Sulphur 33·78 Arsenic 15·63 Copper 50·59 = 100.

The ore was discovered by Oscar M. Lieber, Geol. Survey of S. Carolina.

Epidote [p. 206 and II, II].—The *zoisite* of the Saualpe in Carinthia, analyzed by Klaproth has been recently examined by Rammelsberg (Pogg. c, 133). The angles closely approximate to those of epidote, if the axis supposed by Brooke to be the orthodiagonal is the clinodiagonal, that is, if the prism be turned around 90°, 116° 16′, given as the prismatic angle of zoisite, being nearly the supplement of 63° 8′, the angle $I : I$ of Epidote, and $I$ on the cleavage plane being in the former 121° 52′, in the latter 121° 34′. Analyses of Zoisite of different localities by Rammelsberg:

| | Si | Al | Fe | Ca | Mg | |
|---|---|---|---|---|---|---|
| 1. Saualpe, | 41·51 | 28·90 | 3·98 | 24·78 | 0·58 | =99·75, G.=3·353 |
| 2. Fichtelgebirge, | 41·18 | 30·40 | 2·83 | 24·87 | 0·25 | =99·53, G.=3·361 |
| 3. Goshen, Mass. | 40·98 | 31·38 | 2·51 | 24·46 | 0·50 | =99·83, G.=3·341 |
| 4. Sterzing, | 40·82 | 30·97 | 2·11 | 24·65 | 0·24 | =98·79, G.=3·352 |
| 5. Thal Fusch, | 43·52 | 28·19 | 3·05 | 23·60 | 1·26 | =99·62, G.=3·251 |
| 6. Monte Rosa, | 43·74 | 29·23 | 3·18 | 22·31 | 0·59, K 0·93 | =99·98, G.=3·280 |

The above in each case, the mean of two analyses, after excluding the moisture driven off by ignition. Amount of this moisture in 1, 2·09 p. c.; 2, 2·08; 3, 2·25; 5, 3·67; 6, 3·18. Oxygen ratio for Ṙ, R̈, S̈i, very nearly 1 : 2 : 3, agreeing with epidote, and giving the formula, $\dot{C}a^3\,\ddot{S}i + 2\ddot{A}l\,\ddot{S}i$.

A *mangan-epidote* from St. Marcel, analyzed by Deville, afforded:

| Si | Al | Fe | Mn | Ca | Mg |
|---|---|---|---|---|---|
| 37·3 | 15·9 | 4·8 | 19·0 | 22·8 | 0·2 = 100 |

giving the oxygen ratio for Ṙ, R̈, S̈i 6·59 : 14·54 : 19·3 = 1 : 2 : 3.

Epistilbite [p. 330].—The Berufiord crystals gave von Waltershausen (Pogg. xcix, 171), $1\breve{1} : 1\breve{1}$ (top) = 100° 13′, $I : I$ = 135° 34′; $2\breve{2} : 2\breve{2}$ (adjacent over brachyd. pyramidal edge) 117° 30′.

According to an analysis by C. A. Kurlbaum, Jr., the Iceland epistilbite contains (Am. J. Sci. [2], xxiii, 421):

S̈i 58·74 Ä1 17·10 F̈e 0·12 Ċa 7·81 Ṅa 2·05 K̇ 0·19 Ḣ 14·21 = 100·23

Eudialyte [p. 181].—Damour refers *Eukolite* to Eudialyte. The following are the mean results of his analyses of these two minerals (L'Institut, No. 1201, Jan. 1857):

| | Si | Ta | Zr | Fe | Ca | Mn | Na | Cl | ign. | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Eudialyte, | 50·38 | 0·35 | 15·60 | 6·37 | 9·23 | 1·61 | 13·10 | 1·48 | 1·25 | =99·37 |
| 2. Eukolite, | 45·70 | 2·35 | 14·22 | 6·83 | 9·66 | 2·35 | 11·59 | 1·11 | 1·83 | Ce 2·49, La 1·11 |

No. 1 gives for the oxygen ratio of Ṙ, R̈, S̈i (incl. Ta) 7·75 : 4·10 : 26·20 = 2 : 1 : 6, while No. 2 gives 7·92 : 4·14 : 23·99 = 2 : 1 : 6.

FARÖELITE, *Heddle.*—The zeolite called *mesole* (a name too near *mesolite*), is named Faröelite by Dr. Heddle, and regarded as a distinct species (Phil. Mag. [4], xiii, 53). It occurs associated with mesolite, but is still always distinct from it, being in implanted and isolated globules or hemispheres, sometimes overlaid but never underlaid by the mesolite. The color is usually bluish white and the lustre decidedly pearly, not glassy like the mesolite. It is found at Storr and other places in Skye.

Analyses by Dr. Heddle:

| | Si | Al | Ca | Na | Ḣ |
|---|---|---|---|---|---|
| 1. Storr, | 41·32 | 28·44 | 11·54 | 5·77 | 13·26 = 100·33 |
| 2. Portree, | 41·20 | 30·00 | 11·40 | 4·38 | 13·20 = 100·18 |
| 3. Uig, | 43·17 | 29·30 | 9·82 | 5·33 | 12·40 = 100·02 |

The formula which has been written for mesole [see Min. p. 328] corresponds to the oxygen ratio 1 : 3 : 5 : $\frac{3}{3}$ (ratio deduced by Berzelius), and this is derived by Dr. Heddle from his analyses. In the analyses of the mesole of Annaklef by Hisinger and that of Bombay by Thomson, $1\dot{R} = \frac{1}{2}\dot{C}a + \frac{1}{2}\dot{N}a$; while in that of Faroe according to the analyses of Berzelius and Dr. Heddle, $1\dot{R} = \frac{2}{3}\dot{C}a + \frac{1}{3}\dot{N}a$. The percentage corresponding to the formula is, Silica 42·45, alumina 28·27, lime 10·29, soda 5·75, water 13·24.

[The Hauenstein zeolite, mentioned in Min. p. 328, under Mesole, is stated by Haidinger (as Dr. Heddle observes) to be natrolite coated with comptonite. (See Haidinger's Handbuch, p. 529.) Haidinger on the same page refers mesole to Thomsonite. Berzelius writes for mesole, (from the ratio 1 : 3 : 5 : $\frac{3}{3}$,) the formula

$$[\dot{N}a^3\,\ddot{S}i^2 + 3\ddot{A}l\,\ddot{S}i + 6\dot{H}] + 2[\dot{C}a^3\,\ddot{S}i^2 + 3\ddot{A}l\,\ddot{S}i + 9\dot{H}].$$

The second analysis above by Dr. Heddle corresponds rather better with the ratio, 1 : 3 : $4\frac{1}{2}$ : $2\frac{1}{2}$ (that of a hydrous nepheline) = $\dot{R}^2\,\ddot{S}i + 2\ddot{A}l\,\ddot{S}i + 5\dot{H}$ (in which $2\dot{R}$ =

$\frac{2}{3}\dot{N}a + 1\frac{1}{3}\dot{C}a$) = Silica 40·25, alumina 29·83, lime 10·84, soda 6·00, water 13·08 = 100. Still, the other is probably the true ratio for the mineral.]

FREISLEBENITE [p. 79, and III].—The Freslebenite of Hiendelencina in Spain, according to Mr. Escosura (Revista Minera, vi, 358, Ann. des Mines, [5], viii, 495), occurs with silver glance, red silver, spathic iron, iron and copper pyrites, blende, galena, antimony glance and other ores of lead and silver. G.=5·6--5·7. H.=2·5. Form *trimetric;* the prism is striated and terminates in a brachydome of 120° (top angle). Consists of

| Sulphur | Antimony | Lead | Silver |
|---|---|---|---|
| 17·60 | 26·83 | 31·90 | 22·45 |

GADOLINITE [p. 211].—Hermann points out the homœomorphism of gadolinite and euclase. Both of these species contain glucina, and the oxygen of the bases exceeds that of the silica, the formula corresponding most nearly to $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{3}{4}}$, like that of euclase.—Het. Min. Syst.

GALENA [p. 39, 506, and II, III].—Schwarz has found 6·02 p. c. of cadmium in a galena from Altenberg.—xxxii Ber. der schles. Ges. f. vat. Cultur, 277, in Kenngott's Min. Forsch. f. 1855.

GARNET [p. 190, and I, II, III].—Analyses of garnet by Damour (L'Institut, No. 1198, Dec. 1856):

| | $\ddot{S}i$ | $\ddot{A}l$ | $\ddot{F}e$ | $\dot{C}a$ | $\dot{M}g$ | $Ti^2O^3$ |
|---|---|---|---|---|---|---|
| 1. *Black*, from Frascati, | 35·84 | 6·24 | 23·12 | 32·72 | 1·04 | 1·04=100. |
| 2. *Bottle-green*, Zermatt, | 36·03 | 1·24 | 30·05 | 32·14 | 0·54 | —=100. G.=3·85 |

Damour attributes the color of the first to the presence of the titanium, either as oxyd, or titanic iron.

GIBBSITE [p. 134, 506].—The hydrargillite or crystallized Gibbsite is not hexagonal, according to the examinations of Haidinger.

R. Hermann in his "Heteromeres Mineral-System," continues to describe the Gibbsite as sometimes containing a large percentage of phosphoric acid and therefore a species of doubtful composition, notwithstanding that specimens from Richmond, Mass. have been repeatedly analyzed in this country with reference directly to the phosphoric acid, and none found, or only a trace. Recently a mine of limonite in Chester Co., Pennsylvania, has been found to afford a stalactitic mineral sometimes exceedingly like Gibbsite in external appearance, which is in fact wavellite. It is hence easy to see how M. Hermann may have been led into error, but less so, to comprehend why he and others abroad should persist in it.

GLAUCONITE [p. 288, and III].—The *green grains* of the greensand from the chalk formation in Westphalia afforded W. v. der Marck (Verh. d. nat. Ver., Bonn, 1855, 263):

| $\ddot{S}i$ | $\ddot{A}l$ | $\dot{F}e$ | $\dot{M}g$ | $\dot{K}$ | $\dot{H}$ |
|---|---|---|---|---|---|
| 53·46 | 5·00 | 21·78 | 6·21 | 8·79 | [4·76] = 100. |

Greensand grains from Coal Bluff on the Alabama river and Gainesville, Alabama, afforded J. W. Mallet (this Jour., xxiii, 181), No. 1, a mean of two analyses:

| | $\ddot{S}i$ | $\ddot{A}l$ | $\dot{F}e$ | $\dot{C}a$ | $\dot{M}g$ | $\dot{K}$ | $\dot{H}$ |
|---|---|---|---|---|---|---|---|
| 1. Coal Bluff, | 57·56 | 6·56 | 20·13 | 1·04 | 1·70 | 4·88 | 8·17=100·04 |
| 2. " " | 58·91 | 5·48 | 19·24 | 0·71 | 0·87 | 4·58 | 8·17, Pyrites 1·46= 99·42 |
| 3. Gainesville, | 58·74 | 4·71 | 21·06 | 0·92 | 1·48 | 3·26 | 9·79=99·96 |

11·85 p. c. of the silica in No. 2, insoluble in carbonate of soda, and in No. 3, 23·89 p. c. With the $\dot{F}e$ in No. 3, traces of $\ddot{F}e$. G. of 1, 2·297, of 3, 2·349.

GRAPHITE [p. 29, and II].—On artificial or furnace graphite, by K. C. von Leonhard, Leonh. u. Bronn, 1856, 398. The object of the paper is to show the great extent to which graphite has been found in furnace slags or other furnace products, and point out the bearing of the fact on the graphite of crystalline rocks.

GYPSUM [p. 377, and II, III].—A mineral from Bovenden near Göttingen, which had been called flesh-colored heavy spar, on examination by Dr. C. Schindling, turns out to be gypsum mixed, within, with anhydrite. G.=2·49.—Leonh. u. Bronn, 1856, 664.

HARRISITE [Suppl. III].—N. A. Pratt describes the mode of occurrence and characters of this cubic copper glance in this Jour., xxiii, 409.

Dr. F. A. Genth, in the same volume, p. 415, states reasons for supposing the Harrisite to be a pseudomorph after galena, and mentions an example of this species of pseudomorph described by Breithaupt in his Paragenesis as occurring in Saxony. Dr. Genth obtained in his analyses:

| S | Se | Ag | Cu | Pb | Fe | Insol. |
|---|---|---|---|---|---|---|
| 20·648 | *undet.* | 0·207 | 77·298 | 0·056 | 0·442 | 0·272=98·923 |
| 20·647 | 0·047 | 0·164 | 77·758 | 0·060 | 0·359 | 0·667=99·702 |

Prof. C. U. Shepard sustains Harrisite as a species, in this volume, page 40.

HARTITE [p. 473].—The figure given on page 473 for a crystal of this species belongs to Scheererite and was so published by Haidinger.

G. A. Kenngott has examined some microscopic tabular crystals of hartite obtained from an alcoholic solution (Jahrb. k. k. Geol. Reichs., 1856, p. 91), and found the angle of the plates about 99½° and 80½°; the acute angle of the plates replaced, making the base hexagonal; the angle this side forms with the longer side of the hexagon is 117½°, with shorter 143°. The hartite has been found in Brown coal at Rosenthal near Köflach in Styria. The largest pieces are three-fourths of an inch through. Cleavage perfect in one direction. Haidinger describes the cleavage as perfect parallel to the base of the crystals. Grayish-white to colorless; vitreous lustre but pearly on a cleavage surface. G.=1·036, 1·054, 1·060 (three specimens) Kenngott, 1·041 Baumert. Fuses, according to Baumert, at 72° C. when pure. Melted on paper it leaves a stain which is wholly dissipated with more heat. Composition, according to Baumert, Carbon 87·77, hydrogen 12·26 (mean of results)=100·03, corresponding to the formula $C^6H^5$=carbon 87·80, hydrogen 12·20, the same that was deduced by Schrötter for the hartite of Oberhart.

HEMATITE [p. 113, 506, and II, III].—Pseudomorphs of hematite (specular iron) after octahedrons of magnetite occur in granite near Schönberg, in Northern Moravia. They resemble Breithaupt's *Martite*.—E. F. Glocker, Pogg., xcvi, 262.

HESSITE or TELLURIC SILVER [p. 44 and 506].—Kokscharov observes (Min. Russl., ii, 183) that hessite occurs in fine, or rarely coarse, granular masses, with an even fracture and no distinct cleavage. G.=8·565, Rose. It occurs with blende, copper and iron pyrites, and sometimes telluric lead.

Telluret of silver has been found at Georgetown in California, according to W. P. Blake (this Jour., [2], xxiii, 270). It resembles silver glance, and is mixed with galena and native gold. The texture is compact and not granular. The blowpipe trials of Mr. Blake obtained telluric acid, and this result has been repeated by Prof. G. J. Brush who obtains for the specific gravity [communicated] 8·33. It is not certain that the species is identical with hessite, although quite probable.

HEULANDITE [p. 330].—Descloizeaux confirms on optical grounds, the union of *beaumontite* with heulandite.—L'Institut, No. 1207.

HORNBLENDE [p. 170, and I, II, III].—A columnar or fibrous mineral from Dannemora, described by A. Erdmann, has been named *Dannemorite* by Kenngott (Min. Forsch., 1855). Yellowish-brown to greenish-gray. G.=3·516. B.B. becomes black and fuses on the edges. Contains—

| | $\ddot{S}i$ | $\ddot{A}l$ | $\dot{C}a$ | $\dot{M}g$ | $\dot{M}n$ | $\dot{F}e$ |
|---|---|---|---|---|---|---|
| | 48·89 | 1·46 | 0·73 | 2·92 | 8·46 | 38·21 |
| Oxygen, | 25·38 | 0·66 | 0·20 | 1·14 | 1·90 | 8·48 |

It is nearly pure iron-hornblende.

*Crocidolite* occurs in the Minette of the Vosges (see under *Mica* beyond), according to Delesse (L'Institut, No. 1216). It gave him:

| | $\ddot{S}i$ | $\ddot{A}l$ | $\dot{F}e$ | $\dot{M}n$ | $\dot{C}a$ | $\dot{M}g$ | $\dot{N}a$ | $\dot{K}$ | $\dot{H}$ | Cl | $\ddot{P}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 53·02 | *trace* | 25·62 | 0·50 | 1·10 | 10·14 | 5·69 | 0·39 | 2·52 | 0·41 | 0·17=99·56 |
| Oxygen, | 27·55 | | 5·83 | 0·11 | 0·31 | 3·92 | 1·46 | 0·07 | | | |

giving the hornblende ratio for the oxygen of $\dot{R}$ and $\ddot{S}i$, 4 : 9. Crocidolite appears therefore to be a hornblende. The African variety contains more water.

HYPOXANTHITE, *Rowney.*—The "Sienna earth" has thus been named by T. H. Rowney (Ed. Phil. Jour., [2], ii, 308). It is a brownish-yellow ferruginous clay, probably a mere mixture. G.=3·46. B.B. infusible. Analysis obtained, $\ddot{S}i$ 11·14, $\ddot{A}l$ 9·47, $\ddot{F}e$ 65·35, $\dot{C}a$ 0·53, $\dot{M}g$ 0·03, $\dot{H}$ 13·00 = 99·52.

Iodine.—M. Bornemann states that he has proved the presence of iodine in a free state in the vapors of the fumaroles of Vulcano (north of Sicily).—L'Institut, No. 1205. A white paper was turned blue by the gases, and iodine was found to have the same effect on the paper.

Kerargyrite or Horn Silver [p. 92].—Occurs in Russia in the Altai at the mine Smeinogorsk in pieces sometimes two fingers thick; also at the mine Krukowskoi, Kokscharov, Min. Russl., ii, 284.

Lanthanite [p. 456, and I, III].—Analysis by Dr. F. A. Genth (Am. J. Sci., [2], xxiii, 425), $\dot{C}$ 21·08, $\ddot{L}a$ 54·95, $\dot{H}$ (from the loss) 23·97=100. G.=2·605. In another trial, $\ddot{L}a$ 54·83. Confirms the examination by W. P. Blake. Announced by Prof. Shepard as occurring at the Canton Mine, Georgia, in this volume, p. 43.

Laumontite [p. 307].—The Laumontite of Sarnthal near Botzen in Tyrol, has been analyzed by H. Gericke, as follows (Ann. Ch. Pharm., xcix, 110):

| | $\ddot{S}i$ | $\ddot{A}l$ | $\ddot{F}e$ | $\dot{C}a$ | $\dot{N}a$ | $\dot{H}$ | |
|---|---|---|---|---|---|---|---|
| 1. | 54·025 | 22·405 | 0·194 | 11·775 | 1·309 | 10·993=100·701. | G.=2·280. |
| 2. | 53·328 | 20·775 | 0·336 | 12·185 | 2·538 | 10·448= 99·610. | G.=2·281. |
| 3. | 54·484 | 21·562 | 0·274 | 12·146 | 1·086 | 12·185=101·737. | G.=2·280. |
| 4. | 53·161 | 22·757 | 0·149 | 9·334 | 3·316 | 11·899=100·616. | G.=2 310. |

No. 1, crystalline-foliated aggregate, somewhat altered; 2, fine crystal fragments; 3, still less altered, the fracture showing an especially fresh surface. Oxygen ratio in 1 and 2, for $\dot{R}$, $\ddot{R}$, $\ddot{S}i$, $\dot{H}$, $1:3:8:\frac{8}{3}$; for 3 and 4, 1 : 3 : 8 : 3, the last giving the Laumontite formula, excepting a deficiency of water, viz. $\dot{C}a^3\,\ddot{S}i^2+3\ddot{A}l\,\ddot{S}i^2+9\dot{H}$. But supposing that the Laumontite loses part of its water at 100° C., which H. Rose asserts, and estimating the water existing near that temperature, the three trials afforded 15·759, 16·194, 15·338 p. c. of water, giving the usual formula, or the above excepting $12\dot{H}$ in place of $9\dot{H}$. Prof. Naumann has found the angle of the prism to be 86° 15′, confirming the conclusion from the analyses that the mineral is Laumontite.

The Caporcianite of Savi, Gericke observes is probably nothing but a Laumontite which has lost part of its water. The angle also in Leonhardite, according to Brooke and Miller, is 86° 15′.

The zeolite, from the Island of Skye, analyzed by Prof. Mallet (Am. J. Sci., [2], xxii, 179), has been shown by Dr. Heddle (Phil. Mag. [4], xii, 552) to be Laumontite. Laumontite occurs at that locality in veins about one inch in thickness, having a granular structure arising from an aggregation of minute crystals.

Native Lead [p. 17 and III].—Native lead, according to G. A. Stein (Wöhler, in Ann. d. Ch. u. Pharm., c, 127), occurs in Mexico, at the mine San Guillermo, near Perote (Vera Cruz). It occurs in laminæ in a thin foliated galena which contains 2 to 3 ounces of silver to the hundred weight.

Leucophane [p. 182, and II].—Rammelsberg (Pogg., xcviii, 257) refers leucophane to melinophane of Scheerer. Analysis afforded him:

| | $\ddot{S}i$ | $\ddot{B}e$ | $\ddot{A}l$ | $\dot{C}a$ | $\dot{M}g$ | $\dot{N}a$ | $\dot{K}$ | F | $\dot{H}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leucophane, | 47·03 | 10 70 | 1·03 | 23·37 | 0·17 | 11·26 | 0·30 | 6·57 | —— | =100 43. G.=2·964. |
| 2. Melinophane, | 43 66 | 11·74 | 1·57[a] | 26·74 | 0·11 | 8·55 | 1·40 | 5·73 | 0·30 | = 99·80. G.=3·018. |

[a] With traces of $\ddot{F}e$ and $\ddot{M}n$.

The oxygen ratio for $\dot{R}$, $\ddot{R}$, $\ddot{S}i$ in 1, is 9·65 : 7·26 : 24·42, and in 2, 10·07 : 8·17 : 22·67. But supposing the fluorine united to the sodium, it reduces 1 to 6·71 : 7·26 : 24·42; and 2 to 7·64 : 8·17 : 22·67, approximating to the formula $\dot{C}a^3\,\ddot{S}i^2+\ddot{B}e\,\ddot{S}i+Na\,F$.

[Supposing the fluorid of sodium to act as a base in the silicate, like the protoxyds, and reckoning together the fluorine and the oxygen of these bases, the proportion becomes for 1, 14·95 : 7·26 : 24·24; for 2, 14·68 : 8·17 : 22·67. And in this

case, the ratio, between the oxygen of the silica and the oxygen and fluorine of the bases, is nearly 1 : 1, as in idocrase and epidote, and the formula nearly $2\dot{R}^3\ddot{S}i+\dddot{R}\ddot{S}i$, like that of mellilite. Descloizeaux has stated that melinophane is optically uniaxial, like idocrase, while leucophane is trimetric; and this throws doubt over the indentity.—D.]

Lievrite [p. 262].—Planes and angles of an Elba crystal according to Descloizeaux (Annales des Mines, [5], viii, 402).—$O$, $1\bar{\imath}$, $3\bar{\imath}$, $i\bar{\imath}$, $3\bar{3}$, $2\bar{2}$, $i\bar{2}$, 1, $I$, $2\breve{2}$, $i\breve{2}$, $3\breve{3}$, $i\breve{3}$, $i\frac{5}{3}$ ? $i\breve{4}$, $2\breve{\imath}$, $i\breve{\imath}$. $I : I$=112° 38′, calculated from the observed angles of the dome $1\bar{\imath}$ and octahedron 1, both affording good faces; but about 111° observed. $O : 1\bar{\imath}$= 146° 24′, $O : 2\bar{\imath}$=138° 29′, 1 : 1 (brachyd.)=117° 27′ (observed 117° 23′ to 117° 31′); 1 : 1 (over base) 102° 48′ (observed 102° 44′ to 102° 52′). A full table of angles of the planes is given in the article.

Analysis of the Lievrite of Herbornseelbach in Nassau, by E. Tobler (Ann d. Ch. xcix, 122):

| $\ddot{S}i$ | $\dddot{F}e$ | $\dot{F}e$ | $\dot{M}n$ | $\dot{C}a$ | $\dot{H}$ |
|---|---|---|---|---|---|
| 33·30 | 22·57 | 24·02 | 6·78 | 11·68 | 1·12 = 99·47 |

which corresponds to the formula $3(\frac{1}{3}\dot{C}a^3+\frac{2}{3}\dot{F}e^3)\ddot{S}i+2\dddot{F}e\ddot{S}i$. It occurs in crystals, mostly of the form $\infty$-$\breve{2}$, 1-$\bar{\infty}$, $\infty$, 1; also columnar and massive. H.=6. G.= 3·711, or less than other lievrite, owing to the presence of manganese.

Limonite [p. 131, and II].—Analyses of limonite of Kentucky, by R. Peter, in Owen's Rep. Geol. Ky., 1856.

Linnæite [p. 67].—Analyses (1.) of Copper-linnæite (or Carrollite) from the Patapsco Mine, Maryland; and of Nickel-linnæite (or Siegenite) (2, 3,) from Mineral Hill, Md., and (4) from Mine La Motte, Missouri by Genth (this Jour., xxiii, 418):

| | S | Cu | Ni | Co | Fe | | |
|---|---|---|---|---|---|---|---|
| 1. Carrollite, Md., | 41·71 | 17·55 | 1·70 | 38·70 | 0·46 | Quartz | 0·07=100·19 |
| 2. Siegenite, " | 39 70 | 2·23 | 29·56 | 25·69 | 1·96 | Insol. | 0·45= 99·59 |
| 3. " " | 41·15 | 3·63 | 50·76 | | 3·20 | " | 1·26=100 |
| 4. Siegenite, Mo., | 41·54 | — | 30·53 | 21·34 | 3·37 | " | 1·07, Pb 0·39= 98·24 |

In 2, the copper and iron indicate the presence of 6·42 p. c. of chalcopyrite, and in 3, 10·49 p. c. These ores dissolve slowly in nitric acid *without* a separation of sulphur.

Magnetite [p. 105].—*Professor Nöggerath has described a specimen of spathic iron changed to magnetite* (Bonn. Verh. d. Nat. Ver., 1856, p. lxxvii). It was from Alte Birke near Siegen.

Margarite [p. 300].—Six-sided tables occur in the Pfitsch valley, Tyrol, according to Girard (Zeitsch. f. ges. Nat., v, 301, in Kenngott's Forsch. for 1855). Analysis by Faltin:

| $\ddot{S}i$ | $\ddot{A}l$ | $\dddot{F}e$ | $\dot{C}a$ | $\dot{M}g$ | $\dot{N}a$ | $\dot{K}$ | F | $\dot{H}$ |
|---|---|---|---|---|---|---|---|---|
| 29·57 | 52·63 | 1·61 | 10·79 | 0·64 | 0·74 | 0·44 | 0·13 | 3·20=99·75 |

Marcylite [Suppl. II].—This amorphous black copper ore described by Shepard is apparently an impure atacamite. In an imperfect trial, Shepard obtained, Copper 54·30, O and Cl 36·20, $\dot{H}$ 9·50; and the atacamite contains copper 59·0, O and Cl 28·3, water 12·7.—J. D. D.

Mica [p. 217, and I, II].—The rose-colored mica of Goshen, Mass., has been examined by J. W. Mallet (this Jour., xxiii, 180), and found to contain less than one per cent of lithia. It afforded him, $\dot{K}$ 9·08, $\dot{N}a$ 0·99, $\dot{L}i$ 0·64. Calculating from the loss, this mica gave 1·89 p. c. of fluorine. In the blowpipe trials of Prof. Silliman Jr., *in 1848, he found little lithia, and on this authority the Mineralogy states* (p. 227), as observed by Prof. Mallet, that the mica might not be lepidolite.

A Vesuvian mica has been examined crystallographically by Kokscharov (Min. Russl., ii, 126, 291). The crystals are much like those of muscovite, being seemingly oblique [nearly like fig. 409 Min. p. 221] with $O : I$=98° 38½′, and $O$ : e = 106° 53½′. But taking the form as trimetric, these lateral planes are planes of the octahedrons 2 and 1. *There is also the clinodome* $\frac{4}{3}\breve{\imath}$, *the faces inclined to* $P$ 114° 29′. But Kokscharov shows that the planes $\frac{4}{3}\breve{\imath}$ and 1 have a simple axial ratio, such that $\frac{2}{3}\breve{\imath} : O$ is the same angle as $O : 1$, or 106° 53½, [a necessary result in a

prism of 120°], and hence questions whether the form is not hexagonal. Examined optically it gave a simple black cross.—Grailich gives for the angle between the optical axes in a Vesuvian mica of a pistachio and clear green color, 1°: brownish-green, 2°; bluish, 3°; greenish-black in pumice, 4° (Krystallog., p. 284).

The composition by Kjerulf's analysis of green Vesuvian crystals, is (J. f. pr. Ch., lxv, 190):

| Si̇ | Ä̇l | F̈e | Ṁg | Ṅa | K̇ | ign. |
|---|---|---|---|---|---|---|
| 44·63 | 19·04 | 4·92 | 20·89 | 2·05 | 6·97 | 0·17=98·67 |

Specimen probably impure from mixture with augite. Other Vesuvian micas have afforded the composition of biotite, and this may be similar.

A *biotite*, one of the constituents of a rock from the Vosges called *Minette* (consisting of biotite and orthoclase, disseminated in a feldspathic base, and containing also hornblende, and occurring in dykes intersecting even the Devonian), has been analyzed by M. Delesse, who obtained (L'Institut, No. 1216, April, 1857):

| Si̇ | Ä̇l | M̈n | F̈e | Ḟe | Ċa | Ṁg | K̇ | Ṅa | L̇i | F | Ḣ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 41·20 | 12·37 | 1·67 | 6·03 | 3·48 | 1·63 | 19·03 | 7·94 | 1·28 | 0·22 | 1·06 | 2·90=98·81 |

affording him the formula $\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i$.

The biotite of Slüdianka, near Lake Baikal, has the form of some muscovites, the sides of the tables consisting, according to Kokscharov (Min. Russl., ii, 145), of two planes [like the two *I* and e in fig. 409, Min., p. 221], regarded as the two pyramids 1 and 2; *O*: 1=about 107, *O*: 2=99°. In another crystal there is between *O* and 1 the pyramid $\frac{1}{3}$; *O*: $\frac{1}{3}$=132° nearly. The mica is biaxial, but the angle between the axes is very small.

A pseudomorph of mica after orthoclase, from Lomnitz, afforded von Rath (Pogg. xcviii, 280):

| | Si̇ | Ä̇l | F̈e | Ċa | Ṁg | Ṅa | K̇ | Ḣ | ign. |
|---|---|---|---|---|---|---|---|---|---|
| 1. Mean of results, | 49·04 | 29·01 | 5·56 | 0·17 | 0·75 | 0·50 | 11·19 | 1·16 | 3·49=100·87 |
| 2. Unaltered orthoclase, | 66·66 | 18·86 | 0·46 | 0·36 | 0·21 | 3 01 | 11·12 | — | 0·50=101·18 |

The oxygen ratio for the mica is $\dot{R}:\ddot{R}:\ddot{S}i=1:4{\cdot}83:10{\cdot}74$. The ratio is peculiar for a mica, being known thus far only in one of uncertain locality analyzed by Rammelsberg [see Min., p. 224, anal. 8], and a mica pseudomorph after scapolite analyzed by von Rath [see Min., p. 204, anal. 13, in which place ĊaC̈=11·11 should be added]. —This last analysis, omitting the ĊaC̈, becomes

| | Si̇ | Ä̇l | F̈e | Ċa | Ṁg | Ṅa | K̇ | Ḣ | |
|---|---|---|---|---|---|---|---|---|---|
| 1. Mica pseud., | 49·5 | 27·5 | —— | 15·0 | —— | 8·0 | —— | —— | =100 |
| 2. Unalt'd scapolite, | 50·55 | 28·29 | 5·50 | 2·43 | 0·41 | 1·26 | 7·62 | 3·91 | = 99·97 |

[The orthoclase mica has nearly the *augitic* ratio of 1 : 2 for the oxygen of the bases and silica.]

MORONOLITE, *Shepard.*—In Shepard's Min., p. iv, is the description of some ovoidal or flat concretions under the name *moronolite* (from μωρος, a *mulberry*). The concretions were obtained from the under side of a mass of gneiss. They have a coating of impure hyalite, and with it "is intermixed what appears to be an oxalate and carbonate of lime," of a yellowish color; H.=3·5, G.=2·62; in a tube yields water with some organic odor. In platinum forceps blackens and becomes magnetic; the globule after a few hours in the air gathers moisture which has the taste of sulphate of iron. [No reactions are given which prove that oxalic acid is present, and there is no analysis of the substance as to any of its ingredients. It is difficult to see on what its right to being considered a species rests.—J. D. D.]

MOLYBDENITE [p. 66, and I].—According to Kokscharov, the crystals of molybdenite are monoclinic or perhaps trimetric. He figures hexagonal plates which are compound crystals made up of six sectors by as many radii, with striæ at right angles to the sides of the hexagon. Min. Russl. ii.

NEPAULITE, *Piddington.*—A mineral described by Piddington in the Journ. Asiat. Soc. Bengal, 1854 (Kenngott's Min. Forsch. for 1855). The results of the analysis are much against the species. They are, S̈i 3·60, S 1·60, B̈i S̈i? 84·80, Ċu and C̈ 22·96, Ḟe C̈ 25·62, C̈e 9·40, L̈a 2·80 with a trace of silver = 100·78. H.= 5–6. G.=4·5. Metallic in lustre, granular, slightly foliated. Powder grayish-black, not magnetic. B.B. infusible. Found in masses three-fourths of an inch thick, with quartz, orthoclase, a cerium ore, chlorite.

NITRAMMITE.—Prof. Shepard (his Min. p. v) gives this name to nitrate of ammonia, which he states he has detected in the nitrous earth of the cavern at Nicojack, Tennessee.

Opal [p. 151, and III].—Prof. Shepard describes under the name of *Glossecollite*, a milk-white hydrated silica, for which he writes the formula $\ddot{S}i\dot{H}$, and states that it loses 17 per cent of water by ignition. [This is the composition obtained by von Kobell for the *Michaelite* ($\ddot{S}i$ 83·65, $\dot{H}$ 16·35)]. It occurs earthy compact and white or brownish, yellowish; adheres to the tongue (to which the name Glossecollite alludes). H.=2—2·5. G.=2·2 (but 1·7 if previously varnished). It constitutes a seam an inch thick in a siliceous rock belonging to the Upper Silurian, and "appears to have originated in the alteration of a layer of hornstone." Found 2½ miles south of Rising Fawn, Dade Co., Georgia. Shep. Min. p. iii.

Palladium Ochre.—The palladium ochre, which has still a doubtful existence, is called *Palladinite* in Shepard's Min., p. 408.

PARASITE.—A name given by O. Volger to a borate resulting from the alteration of boracite, probably containing magnesia, water and boracic acid. It is in feathery crystallizations within the boracite crystals, and is optically biaxial probably.—Pogg., xcii, 77.

Parastilbite [p. 332].—Von Waltershausen adds the following to his description of this mineral (Pogg. xcix, 170).—Form trimetric, resembling epistilbite [see Min., p. 330], $1\breve{1} : 1\breve{1}$ (top) =110° 51′; $2\breve{2} : 2\breve{2}$ (over brachyd. pyramidal edge) 136° 38·7′.

PARATHORITE, *Shepard.*—Described by Shepard (Shep. Min., 287) as occurring in minute pitch-black crystals, which are square prisms (*ii*) with truncated lateral edges (*I*), and pyramidal terminations; the pyramids consisting of the planes of two octahedrons *m* and *m′*, in the same vertical series with *I*. *m* (face of the terminal octahedron) : *ii*=130°; *m* : *m′*=160°; *I* : *ii*=135°; *ii* : *ii*=90°. Faces bright. Cleavage imperfect. H.=5—6. B.B. infusible but turns brownish-red, and has a semi-fused aspect at the point most heated; with borax fuses easily to a glass colored by iron. Found at Danbury, Ct. with danburite and oligoclase, and named from a supposed resemblance to thorite.

[This mineral was first described by Prof. Shepard as *Thorite* in the Proceedings of the American Assoc., iv, 321 (New Haven meeting). The crystal figured is there stated to be $\frac{1}{20}$ in. long, and but one of the octahedral planes *m′* was observed. *m* : *ii* is there given as 120° and not 130°. The form was obscure and irregular as the angles given show, since 98° for *m* : *m* would not give 120° for *m* : *ii*; moreover it would give 158° 7′ for *m* : *I* (the prism), while 160° is stated to be the angle of *m* : *m′*, making *m′* nearly coincident with *I*, which it is far from being in the figure. Having examined minute crystals of this mineral from Danbury, I find the form to be trimetric, the crystals being either rhombic or rectangular prisms. One of them, a rectangular prism with replaced edges, has a general resemblance in the terminating planes to the form figured by Professor Shepard, although too indistinct, owing to the curving surfaces of a considerable part of the summit to be satisfactorily figured. Another, a very regular rhombic prism, having the acute edges truncated, gave for the prism the angle 128°; and for the prismatic planes on $i\breve{i}$ 116°. The crystals vary in color from pitch-black to translucent garnet-red, and even in the black crystals splinters or thin edges have often a ruby translucence a little like rutile. They are very commonly imbedded in the Danburite. The following are the blowpipe characters as communicated for this place by Prof. G. J. Brush.—J. D. D.]

*Note on the blowpipe characters of Parathorite, by G. J. Brush.*—In the matrass decrepitates slightly, but does not appear to contain water. In the platinum forceps glows, fuses with difficulty on the edges, and becomes paler. In borax dissolves to a bead which is yellow (due to iron) while hot, and colorless on cooling. With salt of phosphorus gives a bead in the outer flame, which is yellow while hot and colorless on cooling. In the inner flame the bead assumes a delicate violet color (titanic acid?). Hardness about 5. The crystal examined minute.

Pennine.—See *Chlorite*.

Perofskite [p. 345 and II].—In mentioning the remarkable locality of Perofskite found in the valley of Zermatt, in Supplement II, it should have been added that

this new discovery was made by M. J. A. Hugard, assistant in the mineralogical department in the Muséum d'Histoire Naturelle, Paris. Some of the crystalline masses obtained by him were as large as the fist; and while black externally, they are pale brownish-yellow to nearly colorless within. The crystals are peculiarly fine and of interesting forms. The rock or gangue is a talcose schist of a greenish color.

Piauzite [p. 469, and III].—Kenngott gives a fuller account of the piauzite of Tuffer in the Jahrb. k. k. Geol. Reichs., 1856, p. 91. The color of this slaty coal-like resin is brownish to greenish-black; the thinnest splinters colophonite-brown by transmitted light. Streak light to amber-brown. G.=1·186.

Pitchblende [p. 107].—The coracite of LeConte is referred to pitchblende by Dr. F. A. Genth. Analysis afforded (Am. J. Sci. [2], xxiii, 421):

| Ü | Ü | Fe | Al | Mg | Ca | Pb | Si | C and H |
|---|---|---|---|---|---|---|---|---|
| 46·21 | 16·47 | 3·51 | 0·52 | 0·56 | 5·33 | 7·39 | 13·15 | 6·14 = 99·28 |

The ratio of oxygen in UO to $U_2O^3$ is very near 1 : 4.

Plumbic Ochre [p. 109].—The Plumbic ochre occurs with native lead in Mexico at the mine San Guillermo [see Lead] in granular masses of brownish-red, grayish or yellowish color; G.=7·98—7·83. Composition according to Dr. Pugh—

| Pb | Fe | C | Si | S and loss |
|---|---|---|---|---|
| 92·91 | 5·57 | 1·38 | *trace* | 0·14 |
| 92·40 | 4·85 | 1·38 | 0·14 | 1·23 |

[This appears to be the same announced by Prof. Bailey.—See Min., p. 109.]

Plumbo-resinite [p. 431].—Under the name of *Hitchcockite* [Suppl. III], Shepard has described (Min., p. 401) a mineral related to Plumbo-resinite. It occurs at the Canton mine, Georgia, upon the joints of mica-slate, in thin coatings somewhat botryoidal, with the aspect of allophane, and either white or bluish, yellowish or greenish; transparent to translucent; streak uncolored. H.=2·75—3. G.=2·909. In a tube yields moisture. B.B. phosphoresces brightly but is infusible; a rich blue color with nitrate of cobalt; with soda yields zinc. Dissolves without effervescence in warm nitric or hydrochloric acid. Loses 29·45 p. c. at full ignition. Inferred to be a hydrated phosphate of alumina with oxyd of zinc.

Dr. Genth's examinations (Am. J. Sci., xxiii, 424), obtained the following result. G. (at 20° Cels.) about 4·014. With soda on charcoal yields lead and lead incrustations. Composition:

| Pb | Al | Fe | P | H | Ca | C | Cl | Insol. |
|---|---|---|---|---|---|---|---|---|
| 29·04 | 25·54 | 0·90 | 18·74 | 20·86 | 1·44 | 1·98 | 0·04 | 0·48 = 99·02 |
| | 24·69 | 0·68 | | 21·65 | 1·49 | | | 1·11 |

*Oxygen ratio for Pb, R, P, H, 2·08 : 12·18 : 10·50 : 18·55.*

[The compound is analogous to that of plumbo-resinite, consisting of hydrated alumina with phosphate of lead. But the proportions vary in the plumbo-resinite and it is a question as to the definite compound it contains. The same doubt rests over the Canton mineral.

Prof. Shepard has urged (Am. J. Sci., xxiv, 41) that Dr. Genth had not a specimen of the true Hitchcockite; but Dr. Genth has confirmed his determinations (ib. p. 133) with a specimen of the mineral recognized as such by Prof. Shepard. Plumbo-resinite, according to Prof. Shepard, occurs at the Canton mine.

Damour in his paper on Plumbo-resinite (Ann. des Mines, [3], xvii, 191) shows that Berzelius must have precipitated the phosphoric acid along with the alumina and oxyd of lead, and so lost sight of it. In one respect, he observes, the analyses agree,—in the proportion of 1 : 1 between the oxygen of the water and alumina, while the proportion of alumina varies. Damour made three analyses of the Plumbo-resinite of Huelgoet agreeing in these respects:

| | Pb | Al | H | P | Ca | Fe | S | Pb Cl |
|---|---|---|---|---|---|---|---|---|
| 1. | 35·10 | 34·32 | 18·70 | 8 06 | 0·80 | 0·20 | 0·30 | 2·27 = 99·75 |
| 2. | 62·15 | 11·05 | 6·18 | 12·05 | —— | —— | 0 25 | 8·24 = 99·92 |
| 3. | 70·85 | 2·88 | 1·24 | 15·18 | —— | —— | 0 40 | 9·18 = 99·73 |

Dr. Genth's analyses for the Hitchcockite differ from these in affording a proportion of 2 : 5 between the oxygen of the lead and phosphoric acid, and of 2 : 3 between that of the alumina and water, which would be a difference of importance if further analyses should prove that the composition is constant, which is hardly to be expected.—D.]

PYRARGYRITE AND PROUSTITE [p. 77, 78].—From a paper by Q. Sella (Acad. Sci. Torino, 1856), we cite the following crystalline planes of Red Silver, not mentioned in the Mineralogy.—Rhombohedrons $\frac{1}{2}$, $\frac{5}{8}$, $\frac{7}{10}$, $\frac{5}{2}$, $-\frac{1}{8}$, $-\frac{1}{5}$, $-\frac{3}{2}$, $-\frac{7}{2}$, $-14$.—Prisms, $i\frac{16}{25}$, $i\frac{5}{4}$, $i\frac{3}{2}$. Also $-1^{\frac{5}{3}}$, $-\frac{2}{7}^{5}$, $-\frac{1}{5}^{3}$, $-\frac{1}{20}^{13}$, $\frac{2}{3}^{2}$, $\frac{1}{7}^{5}$, $\frac{2}{11}^{4}$, $\frac{1}{4}^{3}$, $\frac{4}{13}^{\frac{5}{2}}$, $\frac{2}{5}^{2}$, $1^{\frac{3}{2}}$, $1^{\frac{5}{3}}$, $1^{\frac{7}{2}}$, $1^{4}$, $1^{\frac{17}{3}}$, $1^{6}$, $\frac{1}{4}^{5}$, $-2^{2}$, $-2^{\frac{7}{3}}$, $10^{\frac{6}{5}}$, $\frac{5}{2}^{\frac{9}{5}}$, $-\frac{1}{5}^{9}$, $-\frac{1}{2}^{2}$, $\frac{1}{3}^{5}$, $\frac{1}{4}^{4}$, $\frac{1}{3}^{3}$, $\frac{5}{8}^{\frac{8}{5}}$, $\frac{5}{8}^{\frac{11}{5}}$, $\frac{1}{2}^{3}$, $\frac{2}{5}^{4}$, $\frac{1}{4}^{7}$, $-\frac{5}{2}^{\frac{9}{5}}$, $-\frac{11}{4}^{\frac{19}{11}}$, $-\frac{7}{2}^{\frac{11}{7}}$, $-4^{\frac{3}{2}}$, $-5^{\frac{1}{5}}$, $-8^{\frac{5}{4}}$, $-\frac{2}{7}^{4}$, $-\frac{1}{2}^{\frac{11}{3}}$, $-5^{\frac{13}{5}}$, $\frac{5}{8}^{3}$, $\frac{11}{8}^{\frac{17}{11}}$, $1\frac{1}{5}^{\frac{23}{11}}$, $\frac{5}{14}^{\frac{19}{5}}$, $\frac{1}{3}^{\frac{17}{3}}$, $2^{3}$, $-\frac{4}{5}^{3}$, $-\frac{1}{2}^{\frac{11}{5}}$, $-\frac{5}{4}^{\frac{12}{5}}$, $-5^{\frac{21}{20}}$. Faces of composition $O$, $\frac{1}{4}$, $R$.

PYRITES [p. 54, and I] —Twins of pyrites of Traversella, etc., figured and described by Q. Sella in Studii sulla Min. Sarda, Turin, 1856.

PYROMORPHITE [p. 400, and II].—Pyromorphite altered to galena and cerusite, at the lead mine of Kautenbach near Berncastel, by Dr. Gergens, Leonh. u. Bronn, N. Jahrb., 1856, 135.

PYROMELANE [Suppl. III].—According to Shepard (Shepard's Min., 3d edit., 253), B.B. infusible, but turns black and becomes opaque. It is soluble in the fluxes with the reaction of titanic acid and iron. [The statement as to the composition given by Prof Shepard ("essentially a titanate of alumina and iron with traces of lime and glucina? with zirconia?") is not deducible from any reactions published by the author.—D.]

PYROCHLORE [p. 345, and II].—Analysis of the fluo-pyrochlore of Miask by Hermann (J. f. pr. Ch., lxviii, 96):—Cb 46·15, Cb 14·68, Ti 4·90, Ce, La 15·23, Y 0·94, Fe 2·23, Ca 9·80, Mg 1·46, K 0·54, Na 2·69, F 2·21=100·83.

QUARTZ [p. 145, and II, III.]—Naumann has given in Leonh. u. Bronn, 1856, p. 146, a review of the crystalline forms of Quartz determined by Descloizeaux, substituting his own symbols. They are as follows [see Min. 145, and figs. 344, for positions of planes.]

1. *Rhombohedrons.* $\frac{1}{2}$, $\frac{2}{3}$, 1, $\frac{11}{10}$, $\frac{9}{8}$, $\frac{8}{7}$, $\frac{7}{6}$, $\frac{6}{5}$, $\frac{16}{13}$, $\frac{5}{4}$, $\frac{13}{10}$, $\frac{4}{3}$, $\frac{11}{8}$, $\frac{3}{2}$, $\frac{5}{3}$, $\frac{13}{7}$, 2, $\frac{7}{3}$, 3, 4, $\frac{13}{3}$, $\frac{14}{3}$, 5, $\frac{11}{2}$, 6, 7, 8, 10, 13, 20, 50, $-30$, $-17$, $-11$, $-10$, $-8$, $-7$, $-6$, $-5$, $-\frac{14}{3}$, $-4$, $-\frac{7}{2}$, $-\frac{13}{4}$, $-3$, $-\frac{20}{7}$, $-\frac{11}{4}$, $-\frac{5}{2}$, $-\frac{7}{3}$, $-\frac{13}{6}$, $-2$, $-\frac{13}{7}$, $-\frac{9}{5}$, $-\frac{5}{3}$, $-\frac{3}{2}$, $-\frac{23}{16}$, $-\frac{7}{5}$, $-\frac{4}{3}$, $-\frac{5}{4}$, $-\frac{6}{5}$, $-\frac{9}{8}$, $-1$, $-\frac{1}{2}$.

2. *Trigonal Pyramids.* $\frac{7}{8}$-2, 1-2, 2-2.

3. *Trigonal Trapezohedrons, or gyroidal forms.*

1. In the zone $-1$, 2·2, $i$.—(1) *below* 2-2 (all positive), 36-$\frac{36}{35}$, 24-$\frac{24}{23}$, 18-$\frac{18}{17}$, 12-$\frac{12}{11}$, 9-$\frac{9}{8}$, 6-$\frac{6}{5}$, 5-$\frac{5}{4}$, 4-$\frac{4}{3}$, $\frac{12}{5}$-$\frac{12}{7}$; (2) *above* 2-2 (all negative), $\frac{11}{6}$-$\frac{11}{6}$, $\frac{9}{5}$-$\frac{9}{5}$, $\frac{12}{7}$-$\frac{12}{7}$, $\frac{3}{2}$-$\frac{3}{2}$, $\frac{4}{3}$-$\frac{4}{3}$, $\frac{5}{4}$-$\frac{5}{4}$, $\frac{6}{5}$-$\frac{6}{5}$, $\frac{7}{6}$-$\frac{7}{6}$, $\frac{8}{7}$-$\frac{8}{7}$, $\frac{10}{9}$-$\frac{10}{9}$, $\frac{12}{11}$-$\frac{12}{11}$, $\frac{15}{14}$-$\frac{15}{14}$; also planes 1-$\frac{9}{7}$, 1-$\frac{3}{2}$.

2. In the zone $R$, 2·2, $i$.—(1) below 2-2, (all negative); $\frac{23}{11}$-$\frac{23}{12}$, $\frac{16}{7}$-$\frac{16}{9}$, $\frac{12}{5}$-$\frac{12}{7}$, $\frac{8}{3}$-$\frac{8}{5}$, 3-$\frac{3}{2}$, $\frac{10}{3}$-$\frac{10}{7}$, $\frac{11}{3}$-$\frac{11}{8}$, 4-$\frac{4}{3}$, $\frac{9}{2}$-$\frac{9}{7}$, $\frac{26}{5}$-$\frac{26}{21}$, 6-$\frac{6}{5}$, $\frac{38}{3}$-$\frac{38}{33}$, $\frac{34}{5}$-$\frac{34}{9}$, 12-$\frac{12}{11}$, 22-$\frac{22}{21}$, 28-$\frac{28}{27}$. (2) Above 2-2 (all positive); $\frac{11}{6}$-$\frac{11}{6}$, $\frac{5}{3}$-$\frac{5}{3}$, $\frac{3}{2}$-$\frac{3}{2}$, $\frac{4}{3}$-$\frac{4}{3}$, $\frac{10}{9}$-$\frac{10}{9}$, $\frac{12}{11}$-$\frac{12}{11}$, $\frac{18}{17}$-$\frac{18}{17}$; also 1-$\frac{6}{5}$, 1-$\frac{3}{2}$.

4. Trapezohedrons, beveling the obtuse or acute edges of $R$. 1-5, 1-$\frac{10}{3}$, $\frac{1}{2}$-$\frac{5}{3}$, $\frac{1}{4}$-3, $-\frac{1}{5}$-3.

5. Prisms $\infty$ (or $i$); $\infty$-2 under a trigonal form; and also the ditrigonal prisms (replacing edges of $i$) $\infty$-$\frac{6}{5}$, $\infty$-$\frac{5}{4}$, $\infty$-$\frac{4}{3}$, $\infty$-$\frac{7}{5}$, $\infty$-$\frac{3}{2}$, $\infty$-$\frac{11}{7}$, $\infty$-$\frac{13}{8}$, $\infty$-$\frac{12}{7}$, $\infty$-$\frac{17}{10}$, $\infty$-$\frac{19}{11}$, $\infty$-$\frac{9}{5}$.

6. Basal plane of prism, or 0.

7. Other trapezohedrons (of which there are 34) whose symbols in Descloizeaux have the form $b^{\frac{1}{v}}$, $b^{\frac{1}{w}}$, $h^{\frac{1}{x}}$, and may be reduced to those of Naumann, by making $\frac{v+w}{s} = m$, and $\frac{v+w}{w} = n$.

The whole number of forms is 166, of which 62 are rhombohedral.

New crystalline faces, Websky, Pogg. xcix, 296, and von Lang, Pogg. c, 351. Also a paper by V. v. Lang (Sitz. Wien, xx, 392) on the faint pyramidal markings on pyramidal planes of quartz crystals, in which he refers them to an initiatory trapezohedron which has for the vertical axis $\frac{1}{3}\frac{1}{3}a$.

Twins of quartz, figured and described by Q. Sella, in Studii sulla Min. Sarda, Turin, 1856.

Salt [p. 90, and II, III].—On borings for salt in Kentucky, Owen's Rep. Geol. Kentucky, 1856.

Samarskite [p. 355, and II].—Analysis by Hermann (J. f. pr. Ch., lxviii, 96): Ëb 44·54, Ċb 11·82, Ṁg 0·50, Ṁn 1·20, Ḟe 8·87, Ü 16·63, Ẏ 13·29, Ċe, Ḽa 2·85, ign. 0·33 =100·03.

Sassolin [p. 144].—Artificial crystals stated to be monoclinic by Kenngott (Sitzungsb. Wien, xii, 26), afford the planes, *I*, *ĭĭ*, *O*, and are twinned parallel to *ĭĭ*. $I : I = 118° 4'$, $I : ĭĭ = 120° 50'$.

Saussurite p. 254, and II].—The saussurite of Zobten, Silesia, according to C. F. Chandler (Inaug. Dissert.. 1856) is snow-white to greenish-white in color, and has an imperfect cleavage with little lustre, and translucent on the edges. H.=6. It occurs with a blackish-green fibrous hornblende regarded as uralite by G. Rose. Composition:

| S̈i | Ä̈l | F̈e | Ċa | Ṁg | Ṅa | K̇ | ign. |
|---|---|---|---|---|---|---|---|
| 51·76 | 26·82 | 1·77 | 12·96 | 0·35 | 4·61 | 0·62 | 0·68 = 99·57 |

Oxygen ratio for Ṙ, R̈, S̈i, 1·17 : 3 : 6·17. G.=2·788—2·791. Von Rath's analysis of the saussurite of Neurode gave 1·31 : 3 : 6·12. Mr. Chandler regards the saussurite as resulting from the decomposition of labradorite.

Savite [p. 316].—According to Breithaupt, Savite is trimetric (not dimetric) and $I : I = 91° 41'$.—Berg. u. Hütt. Zeit. 1855, 223, in Kenngott's Min. Forsch. for 1855. See also under Laumontite.

Schorlomite [p. 342].—Shepard (Shep. Min., 257) makes schorlomite monometric, and gives as a figure a dodecahedron with truncated edges. Black garnets occur with the schorlomite, and it seems possible that the two may have been confounded.

Scolecite [p. 328, and I].—Dr. Heddle has analyzed the lime-and-soda scolecite called *Mesolite*, and regards it as a distinct species. The following are his results (Phil. Mag. [4], xiii, 50, and 148):

| | S̈i | Ä̈l | Ċa | Ṅa | Ḣ |
|---|---|---|---|---|---|
| 1. Talisker, Skye, | 46·714 | 26·617 | 9·078 | 5·389 | 12·831 |
| 2. Storr, Skye, | 46·724 | 26·698 | 8·902 | 5·404 | 12·925 |
| 3. Kilmore, Skye, | 46·26 | 26·48 | 10·00 | 4·98 | 13·04 |
| 4. Naalsöe, Faröe, | 46·80 | 26·46 | 9·08 | 5·14 | 12·28 |
| 5. *Antrimolite*, | 45·98 | 26·18 | 10·78 | 4·54 | 13·00=100·45 |

No 1 is white, in delicate interlacing crystals, called on Skye, cotton stone; 2, in white and delicate feathery tufts; 3, in yellowish white radiated crystals, forming solid masses, resembling natrolite, affording a prism of 91° and 89° according to Greg; 4, in downy tufts.

Oxygen ratio of 1, for Ṅa, Ċa, Ä̈l, S̈i, Ḣ = 1·38 : 2·59 : 12·46 : 24·27 : 11·40; for Ṙ, R̈, S̈i, Ḣ, 1 : 3·13 : 6·11 : 2·89 = 1 : 3 : 6 : $\frac{8}{3}$, in which the lime and soda have the ratio of 2 : 1 or $1\dot{R} = \frac{2}{3}\dot{C}a + \frac{1}{3}\dot{N}a$ [approximately]. The proportion of soda present, and the deficiency of water, suggest that the mineral corresponds to 2 of scolecite and 1 of natrolite = $2[\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i + 3\dot{H}] + [\dot{N}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i + 2\dot{H}]$. [This formula is given for Mesolite by Berzelius in the 4th edition of his work on the blowpipe, p. 165 of the German edition.]

The *red Galactite* of Glen-farg analyzed by Dr. Heddle [see our 2d Suppl.], he referred in his former paper to natrolite. But like the mesolite it is intermediate between natrolite and scolecite in containing both soda and lime, $1R = \frac{2}{3}\dot{N}a + \frac{1}{3}\dot{C}a$ [approximately], and a slight excess of water above that in natrolite, and he proposes for it the name *Fargite*.

The oxygen ratio for $\dot{R}$, $\ddot{R}$, $\ddot{S}i$, $\dot{H}$, in natrolite is 1 : 3 : 6 : 2 and $1\dot{R} = 1\dot{N}a$; for *Fargite*, 1 : 3 : 6 : $2\frac{1}{3}$, and $1\dot{R} = \frac{1}{3}\dot{C}a + \frac{2}{3}\dot{N}a$; for *Mesolite* 1 : 3 : 6 : $2\frac{2}{3}$ and $1\dot{R} = \frac{2}{3}\dot{C}a + \frac{1}{3}\dot{N}a$; for *Scolecite* 1 : 3 : 6 : 3, and $1\dot{R} = 1\dot{C}a$, there being an apparent increase in the water, from 2 to 3 in the ratio, with the increase of the lime. [The analyses of Dr. Heddle vary but little from what the scolecite oxygen ratio (1 : 3 : 6 : 3) requires; $(\frac{1}{3}\dot{N}a + \frac{2}{3}\dot{C}a)\ddot{S}i + \ddot{A}l\ddot{S}i + 3\dot{H}$ = silica 46·25, alumina 25·71, lime 9·35, soda 5·17, water 13·52 = 100. The water exceeds that of analysis 1 by 0·69; of 2, by 0·6; of 3, by 0·48.]

The Antrimolite of Thomson is shown by the analyses to be Mesolite, and not to contain potash, as Thomson's analysis states.

Senarmontite [p. 140].—The octahedral oxyd of antimony occurs in the district of Haractas, Algeria, along with antimony glance (from whose decomposition it has resulted), antimonious acid, and some galena. It is slightly arsenical, and this may account for its taking the octahedral form, since oxyd of arsenic is usually octahedral. These minerals are also mixed with calcite, cerusite, and red antimony, which likewise are a result of modern changes. Fournet, Bull. Geol. Soc. France, 1855, xii, 1039.

Serpentine [p. 282, 511, and I, II, III].—The following note on Antigorite has been communicated for this Supplement by Prof. G. J. Brush.

*Analysis of Antigorite, by Geo. J. Brush.*—In the 1st Supplement allusion is made to the fact that Schweizer has announced that his analyses of antigorite are inaccurate and should therefore be rejected. He states (Pogg. xcii, 495) that from recent examinations made in connection with Stocker-Escher, the loss of weight by heat in two trials was 13·30 and 13·26 p. c., while in his early analyses the amount of water was given as 3·70 p. c.; further, he says that Stocker-Escher is engaged in making a complete analysis of the mineral which in due time will be made public.

As some three years have elapsed since this announcement was made, and so far as I can learn, no analysis has been published, it may not be out of place here to give an analysis that I had occasion to make of this mineral some months since.

The specimen analyzed was obtained from Dr. Krantz. Its physical properties and blowpipe reactions are identical with those given by Schweizer. The mineral was decomposed by carbonate of soda in the usual manner, and special precautions were taken to ensure a complete separation of the magnesia from the iron. The analysis gave:

| $\ddot{S}i$ | $\dot{F}e$ | $\dot{M}g$ | $\dot{N}i, \dot{C}r$ | $\ddot{A}l$ | $\dot{H}$ |
|---|---|---|---|---|---|
| 41·58 | 7·22 | 36·80 | *trace* | 2·60 | 12·67 |

This is the chemical composition of serpentine, and antigorite may be considered therefore as one of its slaty varieties.

*Serpentine marbles.*—Chemical examination by C. T. Jackson, this Journ., xxiii, 123.

Stassfurtite [Suppl. III, under Boracite].—Analysis by C. F. Chandler (Inaug. Dissert.): $\ddot{B}$ 69·18, $\dot{M}g$ 29·93, $\dot{F}e$ 0·89, $\dot{C}a$ *trace* = 100, proving its essential identity in composition with boracite.

Stilpnomelane [p. 287 and III].—A mineral whose characters, as far as can be gathered from the description, approach those of Stilpnomelane, has been described by Shepard (Shep. Min., p. vi) under the name of *Rastolyte*. It resembles a mica, and occurs in an oblique prism, $O : I = 98°$, plane angle of base 120°. Crystals $\frac{1}{2}$ to $1\frac{1}{2}$ inches across. Parallel to *O* foliated; also cleavages *I* and a diagonal. Color ash-grey, reddish; bluish on the diagonal cleavage. Brittle. Yields water and fluorine. B.B. becomes grayish-black and fuses to a black magnetic globule. A trial, admitted to be approximative only, gave, $\ddot{S}i$ 42·30, $\dot{F}e$ 38·25, $\ddot{A}l$ 6·50, $\dot{C}a$ 2·00, $\dot{M}g$ 1·00, $\dot{H}$ and F 3·80, alkali and loss (with some oxygen for part of the iron as peroxyd) 6·15 = 100.

Siegert's analysis of Stilpnomelane gave Si 42·07, Fe 41·98, Al 4·92, Mg 0·94, Ca 1·67, H 8·47=100·05. See Rammelsberg's 5th Suppl., 230, and Dana's Min., p. 288

TACHHYDRITE, *Rammelsberg* (Pogg. xcviii, 261).—A compound of chlorid of lime and chlorid of magnesium, of the formula $CaCl+2MgCl+12\dot{H}$. Analysis afforded Rammelsberg:—

| Cl | Ca | Mg | H |
|---|---|---|---|
| 40·34 | 7·46 | 9·51 | 42·69 = 100 |

Occurs in the salt mine of Stassfurth associated with anhydrite, in roundish masses, transparent to translucent, and of a yellow color. It has at least two distinct cleavages. The name alludes to its ready deliquescence on exposure.

The same locality affords the Martinsite, a granular mixture of chlorid of sodium (90 p. c.) with sulphate of magnesia and anhydrous [Min., p. 90]. There is also a sulphate of magnesia of similar appearance containing but little more than 1 p. c. of water ($\dot{M}g\ddot{S}$+aq.). The analysis afforded Rammelsberg, S 57·7, Mg 26·8, water 15·5. It is mixed with 4 per cent of chlorid of sodium.

TANTALITE [p. 351, and III].—Analysis of the tantalite of Kimito by Hermann (J. f. pr. Ch., lxx, 205): Tantalic acid (Ta) 73·07, columbic acid (Cb) 11·02, Fe 10·08, Fe 3·33, Mn 1·32, Sn 0·70=99·70.

The tantalite from Chanteloube, afforded C. F. Chandler (Inaug. Dissert.), Ta 79·89, Sn 1·51, Zr 1·32, Fe 14·14, Mn 1·82, Ca, Cu *trace*=98·67. Probable oxygen ratio for R, Ta, 1 : 5. G.=7·533.

TOPAZ [p. 259, 512].—Kokscharov has given a large number of fine figures of Russian crystals of topaz in his Min. Russl. (ii, 198, and plates xxix to xxxviii inclusive). He mentions the planes $2\text{-}\breve{2}$, $1\text{-}\breve{3}$, $1\text{-}\breve{\infty}$, $3\text{-}\breve{\infty}$, $\frac{16}{7}\text{-}\breve{\infty}$? and $\frac{4}{3}\text{-}\bar{2}$, which are not mentioned in the Mineralogy. [In these symbols, the fundamental pyramid (1) is that which gives $O:1=134°\ 32'$—taken as the pyramid 2 by Kokscharov.]—According to Kokscharov's measurements, $I:2=153°\ 53'$ ($153°\ 54'\ 8''$ Calc.), $O:\frac{2}{3}=145°\ 47'$ ($145°\ 55'$ Calc.), $\frac{2}{3}:\frac{2}{3}$ (macrod.)$=149°\ 32'$ ($149°\ 31'$ Calc.), $i\breve{2}:i\breve{2}=93°\ 12'$ ($93°\ 10'\ 44''$ Calc.), $I:i\breve{2}$ (over $I$)$=105°\ 34'$ ($105°\ 33'\ 8''$ Calc.), $2\breve{i}:2\breve{i}$ (over top)$=92°\ 42'\ 15''$, $O:2\breve{i}=136°\ 20'\ 47''$, $O:2\breve{i}=118°\ 59'\ 0''$, $O:1=134°\ 24'\ 38''$, $I:1=135°\ 35'\ 10''$, $I:I=124°\ 16'\ 40''$. In 4 crystals from the Ilmengebirge, the variation for $I:I$ was only $1'$, the measurements giving $124°\ 16'\ 10''$, $16'\ 30''$, $17'\ 0''$, $16'\ 0''$. The angles considered the best for calculation, are $I:I=124°\ 17'$, and $O:2\breve{i}=136°\ 21'$.

TOURMALINE [p. 270, and II].—Green tourmalines occur in the valley of Harrach in Algeria.—Bull. Soc. Geol. de France, [2], xiii, 416.

TYRITE [Suppl. I, III].—The question of the reference of Tyrite to Fergusonite by Kenngott is shown by D. Forbes (Phil. Mag., [4], xiii, 91) to require more investigation. The crystals are stated by Forbes to be too rough and imperfect for exact measurement, yet, it is observed, the form may turn out to be the same. The specific gravity is different, being about 0·5 higher in Fergusonite. The composition according to the analyses is different. The following are the results of two analyses by D. Forbes, and one of Fergusonite by Hartwall. The metallic acid of the fergusonite is not known certainly to be tantalic, although so stated.

| | Cb | Y | Ca | Ce | La | Fe | U | Sn | Al | Zr, Be | H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. From Hampemyr, | 44·90 | 29·72 | 0 81 | 5·35 | | 6·26 | 3·03 | | 5·66 | *trace* | 4·52 |
| 2. From Helle, | 44·48 | 27·83 | 1·68 | 5·63 | 1·47 | 2·11 | 5·99 | *trace* | 3·55 | 2 78 | 4·66 |
| 3. *Fergusonite*, | 47·75 | 41·91 | — | 4·68 | Fe 0·34 | U | 0·95 | 1·00 | — | 3·02 | *trace* |

The Fergusonite was examined for water by Hartwall, but none found. The Tyrite crystals appeared to be fresh. They are tetragonal and have their bases in crystals of black mica, and often taper to a point, without facets. One cleavage distinct, and traces of two others. H.=6·5. Brittle. G.=5·36; another crystal not so distinct in cleavage, 5·13. Crystals occasionally 2 inches long. They come from Helle on the mainland at Næskül, about 10 miles east of Arendal, and at Hampemyr on the island Tromoe.

URANITE [p. 430].—The yellow phosphate of uranium is not isomorphous with the green phosphate, according to Descloizeaux (L'Institut, No. 1207), for it has two axes of double refraction, or is trimetric, and not dimetric.

VANADINITE [p. 362, and II, III].—According to Rammelsberg (Pogg. xcviii, 249), occurs in limestone in Carinthia near Windischkappel. Color brownish, the smaller crystals clear yellow; no distinct cleavage; largest crystals 3 mm. long and 1 thick. G.=6·83, Canaval, 6·886, Rammelsberg. Form near that of pyromorphite; hexagonal prism $I(\infty)$ with the pyramids 1, 2, and 2-2. 1 : 1=142° 30′, 2 : 2=129° (approximately); $I$ : 1=130°; $I$ : 2=149° 12′. The angle 1 : 1 in pyromorphite is 142° 12′ according to Miller (142° 15′ from Bleistadt, G. Rose), 141° 3′ from Mies, G. Rose. Rammelsberg obtained on analysis,

| | | | | |
|---|---|---|---|---|
| $\dddot{V}$ 17·41 | $\ddot{P}$ 0·95 | $\dot{P}b$ 69·68 | Pb 6·52 | Cl 2·23 = 96·79 |

the loss in which is stated to be vanadic acid, making for the acid 20·62, and affording very nearly the formula $\dot{P}b^3\ddot{V}+\frac{1}{3}$Pb Cl=Vanadic acid 19·60, oxyd of lead 70·67, lead 7·29, chlorine 2·44.

Kenngott reckons the loss (Pogg. xcix, 95) as oxygen, and makes the acid $VO^5$ instead of $VO^3$, and thus approximates the formula to that of pyromorphite, it becoming $\dot{P}b^3\dddot{V}+\frac{1}{3}$Pb Cl=Vanadic acid ($VO^5$) 20·82, phosphoric acid 0·97, oxyd of lead 69·54, chlorine 2·21, lead 6·46. One-fifteenth of the acid is phosphoric.

Dr. J. Schabus has examined the crystals from Obir near Windischkappel in Carinthia. The different crystals have the following planes.—(1) $I$, 1; (2) $I$, 1, $\frac{5}{2}$; (3) $I$, 1, 2-2; (4) $O$, $I$, 1, $\frac{5}{2}$; (5) $O$, $I$, 1, 1-2. Angle of pyramid 1, 142° 58′ (pyramidal); 78° 52′ (basal, in different crystals 78° 46′—78° 54′); $O$ : 1=140° 34′. Schabus has obtained the following for the corresponding basal angles of mimetene and pyromorphite. *Mimetene from England* 79° 24′; *from Johanngeorgenstadt* 79° 44′, 79° 56′, 80° 4′, 80° 43′; from Zschopau, 80° 11′; from Pennsylvania, 80° 30′; of Pyromorphite from Bleistadt, 80° 40′.—Pogg. c, 297.

VIVIANITE [p. 415, and III].—A massive indigo-blue vivianite from Allentown, Monmouth Co., N. J., contains according to C. A. Kurlbaum, Jr. (Am. J. Sci., [2], xxiii, 422):

| | | | | |
|---|---|---|---|---|
| $\ddot{P}$ 29·65 | $\ddot{F}e$ 18·45 | $\dot{F}e$ 27·62 | $\dot{M}g$ 0·03 | $\dot{H}$ 25·60=101·35 |

WARWICKITE [p. 395, and I].—Prof. Shepard states, in his Mineralogy, that the larger crystals of Warwickite afford BB. fluorine, and contain a large proportion of manganese.

[The examinations of Hunt, and Smith and Brush, of the crystals both large and small, have not detected any fluorine. The original analysis by Prof. Shepard (Am. J. Sci., xxxvi, 87, 1839) is stated to have afforded, Titanium 64·71, iron 7·14, yttrium 0·80, fluorine 27·33, aluminium a *trace*=99·98, in which no manganese is mentioned, besides no magnesia or boracic acid.—D.]

WAVELLITE [p. 423].—At Steamboat, Chester Co., Pa., in a mine of limonite, wavellite has been found in great abundance forming stalactites and in botryoidal forms. The stalactites are one-fourth of an inch or more thick and have a filiform centre of hydrated iron ore. The exterior is sometimes smooth like Gibbsite, which it then closely resembles, but is usually drusy with minute rhombic crystals transparent or nearly so; and frequently coated with another mineral yet undetermined. Dr. Genth has examined the wavellite and obtained for its composition (Am. J. Sci., [2], xxiii, 423):

| | | | | |
|---|---|---|---|---|
| $\ddot{P}$ 34·68 | $\ddot{A}l$ 36·67 | $\dot{H}$ 28·29 | F *trace* | Limonite 0·22 = 99·86 |

[The prisms afford the angle 123°—124°.—D.]

WOLFRAM [p. 351, and I, II, III].—A fine crystal from Zinnwald afforded Weidinger (Zeitschr. Pharm., 1855, 71, Lieb. u. Kopp., 1855, p. 963):

| $\ddot{\ddot{W}}$ | $\ddot{T}i$ | $\dot{F}e$ | $\dot{M}n$ | $\dot{C}a$ | $\dot{H}$ |
|---|---|---|---|---|---|
| 75·62 | 1·89 | 8·73 | 12·17 | 2·27 | 0·31 = 100·99 |

YTTROTANTALITE [p. 359].—This Ytterby mineral contains, according to C. F. Chandler, (Inaug. Dissert.):

$\ddot{T}a$ 57·27, $\ddot{W}$ 1·85, $\ddot{S}n$ 0·10, $\dot{C}a$ 4·78, $\dot{M}g$ 0·75, $\ddot{U}$ 5·10, $\dot{F}e$ 4·82, $\dot{Y}$ 18·64, $\dot{C}u$ 0·69, $\dot{H}$ with a trace of sulphur 6·00=100. Or, excluding the water, $\ddot{T}a$ 60·91, $\ddot{W}$ 1·97, $\ddot{S}n$ 0·11, $\dot{C}a$ 5·09, $\dot{M}g$ 0·80, $\ddot{U}$ 5·42, $\dot{F}e$ 5·13, $\dot{Y}$ 19·84, $\dot{C}u$ 0·73=100.

ZIRCON [p. 195].—In the collection of the Ecole des Mines, there are two crystals of zircon from Brazil (Serro de Frio) which have the pyramidal terminations truncated, and in one this flat terminal or basal plane is very large. G.=4·47—4·41. Mr. Friedel, Ann. des Mines, [5], ix, 629, 1856.

The zircon of Buncombe Co., North Carolina, contains, according to C. F. Chandler (Inaug. Dissert., Gött. 1856):

$\ddot{S}i$ 33·70 $\ddot{Z}r$ 65·30 $\ddot{F}e$ 0·67 $\dot{H}$ 0·41 = 100·08

G. of four crystals, 4·555, 4·578, 4·594, 4·607: the same after ignition, 4·672, 4·661, 4·631, 4·650; loss by ignition, 0·397 to 0·449 p. c.

## ADDENDUM.

ALLOPHANE.—The allophane of New Charlton, near Woolwich, has been analyzed by A. B. Northcote, with the following results (Phil. Mag., [4], xiii, 338):

| | $\ddot{S}i$ | $\ddot{A}l$ | $\dot{F}e$ | $\dot{C}a$ | $\dot{H}$ | $\dot{C}$ | |
|---|---|---|---|---|---|---|---|
| 1. Amber-like variety, | 20·50 | 31·34 | 0·31 | 1·92 | 42·91 | 2·73 = | 99·71 |
| 2. Semi-opaque, friable, | 19·58 | 37·30 | 0·11 | 1·36 | 39·19 | 2·44 = | 99·98 |
| 3. Ibid., | 17·00 | 39·09 | *trace* | 1·50 | 40·92 | 1·49 = | 100 |
| 4. Ruby-red, transparent, | 17·05 | 32·88 | $\ddot{F}e$ 6·59 | 1·34 | 40·31 | 1·82 = | 99·99 |

Excluding the carbonic acid, lime and protoxyd of iron, the oxygen ratio for $\ddot{S}i$, $\ddot{R}$, $\dot{H}$, is as follows:

(1) 1 : 1·37 : 3·58 (2) 1 : 1·71 : 3·42 (3) 1 : 2·06 : 4·11 (4) 1 : 1·96 : 4·0

At 100° C. the loss of water in (1) 27·11, or over 3-5ths of the whole; in (2) 20·76; in (3) 20·10; in (4) 21·97; in the last three about half the whole amount of water. Supposing this water non-essential, the ratios become:

(1) 1 : 1·37 : 1·32 (2) 1 : 1·71 : 1·61 (3) 1 : 2·06 : 2·09 (4) 1 : 1·96 : 1·84.

Mr. Northcote excludes still farther,—as required by his idea of the formula,—from (1), $2\frac{1}{2}\dot{H}$ out of $11\frac{1}{2}\dot{H}$; from (2), $2\dot{H}$ out of $14\dot{H}$; from (3), $3\dot{H}$ out of $18\dot{H}$; from (4), $1\dot{H}$ out of $13\dot{H}$;* and thence has the formulas as follows:

(1) $\ddot{A}l\,\ddot{S}i^3+3\ddot{A}l\,\dot{H}^3$ (2) $\ddot{A}l\,\ddot{S}i^6+4\ddot{A}l\,\dot{H}^3$

(3) $\ddot{A}l\,\ddot{S}i^3+5\ddot{A}l\,\dot{H}^3$ (4) $\ddot{A}l\,\ddot{S}i^3+4(\ddot{A}l,\ddot{F}e)\dot{H}^3$

making them compounds of an unknown silicate and Gibbsite in different proportions.

[This second deduction of water, reduces the several oxygen ratios to 1 : 1·37 : 1·04, 1 : 1·71 : 1·48, 1 : 2·06 : 1·74, 1 : 1·96 : 1·71.

There is so much that is arbitrary in the assumption of 100° C. as the dividing temperature between the stable and unstable water in such hydrates, and also in the rejection of $\frac{1}{12}$th to $\frac{1}{5}$th of the water beyond this, for the sake of a formula, that, for the present, the mere oxygen ratios for given temperatures best represent our *actual* knowledge, and especially as allophane is an amorphous mineral. If a series of experiments were made for successive temperatures from 40° C. to 120° C. (or beyond), and at some point in the line, an abrupt diminution of the water eliminated were found, then one step would be taken towards the discovery of the temperature

* It is difficult to understand how this water here cut off can be regarded as "having probably crept in as an erroneous result," especially as 20 per cent or more of water were before excluded.

limiting the essential and non-essential water. But until this is done, or some other method for the purpose be ascertained and carried out, it is better to acknowledge ignorance than to rely on mere suppositions. The formulas above deduced contain the improbable silicate $\dot{Al}\ddot{Si}^3$ (a silicate least of all to be expected in a compound containing so very little silica), and this gives them an additional hypothetical character. The other member, $\dot{Al}\dot{H}^3$ (Gibbsite), is probable enough; and in fact allophane is often mixed with Gibbsite at the Richmond (Mass.) locality (see Silliman, Am. J. Sci., [2], vii, 411).

As suppositions are easily made, we suggest two or three, to show farther what hypothesis may do. The ratios deduced above, for a temperature of 100° C., are quite nearly—

(1) 3 : 4 : 4 (2) 3 : 5 : 5 (3) 3 : 6 : 6 (4) 3 : 6 : 6

From these ratios we may have the following formulas:

(1) $\dot{Al}\ddot{Si}\dot{H}^8+\frac{1}{3}\dot{Al}\dot{H}^3$ (2) $\dot{Al}\ddot{Si}\dot{H}^3+\frac{2}{3}\dot{Al}\dot{H}^3$ (3) (4) $\dot{Al}\ddot{Si}\dot{H}^3+\dot{Al}\dot{H}^3$

in each of which, the first member is *Halloysite* (a product, like allophane, of the decomposition of feldspar), and the second *Gibbsite*. Adding $n\dot{H}$ after each of the above, any excess of water that the analyses may be regarded as affording might be indicated.

Again, we may suppose that 100° C. may drive off part of the essential water, as in Laumontite (see above). Take the ratios, with a slight alteration as follows:

(1) 3 : 4 : 5 (2) 3 : 5 : 6 (3) (4) 3 : 6 : 7

We then may have the formulas $3\ddot{Si}\dot{H}+4\dot{Al}\dot{H}^3$, $3\ddot{Si}\dot{H}+5\dot{Al}\dot{H}^3$, $3\ddot{Si}\dot{H}+6\dot{Al}\dot{H}^3$, each a compound of hydrated silica (opal) and gibbsite, both known results of feldspar decomposition.

Or, supposing that about half the water driven off at 100° C. were previously in chemical combination, we can make out the ratios—

(1) 3 : 4 : 7 (2) 3 : 5 : 8 (3) (4) 3 : 6 : 9

in which, the oxygen ratio is 1 : 1 for $\ddot{Si}+\dot{Al}$ and $\dot{H}$; and the general formula might then be $(\dot{Al}, \ddot{Si})\dot{H}^3$, or $m\dot{Al}\dot{H}^3+n\ddot{Si}\dot{H}^3$, the last ratio giving $2\dot{Al}\dot{H}^3+\ddot{Si}\dot{H}^3$. Guillemin obtained 35·74 $\dot{H}$ (as Mr. Northcote mentions) *after drying* at 100° C., and his analysis gives the ratio 6 : 9 : 15 (=2$\ddot{Si}$, 3$\dot{Al}$, 15$\dot{H}$), in which there is the same oxygen ratio, 1 : 1, for $\dot{Al}+\ddot{Si}$ and $\dot{H}$,—whence the formula, $3\dot{Al}\dot{H}^3+2\ddot{Si}\dot{H}^3$ or 3 of Gibbsite and 2 of a supposable gelatinous silica.

Or, including the *whole* of the water obtained, all the ratios but the first give for the oxygen of $\ddot{Si}+\dot{Al}$ to that of $\dot{H}$, the ratio 3 : 4, whence the general formula $(\ddot{Si}, \dot{Al})\dot{H}^3+\dot{H}$. $\ddot{Si}$ and $\dot{Al}$ having the proportions 3 : 5 in 2, and 1 : 2 in 3 and 4.

In this way many other suppositions might be made. But until we have a better basis of facts, they avail little to the science. 100° C. is an arbitrary point in the scale of temperature. That it is the point limiting stability in all hydrous compounds is well known to be not the fact; that it is so in any one case, is a question for special research. Science will no doubt ultimately include all compounds, organic and inorganic, under a common system of formulas; but the mineral allophane will not take its true place in the series until it is better understood.—J. D. D.]

## Art. X.—*A few remarks in answer to Prof. C. U. Shepard's "Reply;"* by F. A. Genth.*

Prof. C. U. Shepard in his "Reply to Dr. F. A. Genth's remarks on the Minerals of the Canton Mine" in this number of the Am. J. of Science, endeavors to show that I have mistaken some of his species, and he also blames me for not knowing what he wrote in the second part of his Treatise on Mineralogy, a book of which incomplete copies may have been distributed amongst some personal friends, but which as far as I can learn, has not been advertised in any of the catalogues of the leading booksellers of this country.

I have not time at present to answer his "Reply" in detail. It may suffice to say that I have made a qualitative analysis of a specimen of *genuine* Hitchcockite, which Prof. J. D. Dana was so kind as to send me, and of which he says in his letter, dated New Haven 11th, May 1857, as follows: "I give to the express for your examination a specimen which he (Prof. Shepard) informed me was '*true*' Hitchcockite."

The physical properties are exactly the same as those of the Hitchcockite which I have analyzed, although it is less pure than the material selected for my analyses. Before the blowpipe with carbonate of soda it gives lead incrustations and metallic lead, but no incrustations of zinc whatever. An examination of its solution in chlorhydric acid proved that the mineral contains oxyd of lead, alumina, a trace of sesquioxyd of iron, and phosphoric acid, but not a trace of oxyd of zinc. I may therefore be permitted to presume that if Prof. Shepard has been mistaken in one instance, he may be mistaken in the others of which I spoke in my last Contribution to Mineralogy. However, if Prof. Shepard will satisfy me by genuine specimens of the correctness of his determinations, I will very cheerfully examine them, and publish the results of my investigations.

I do not think the occasional publication of "new minerals" with a loose description attached to them to be of any benefit to science at all, and consider it the duty of every one, who is able to do so, to examine into the merits of alleged new species and to endorse them, if they are really good, and denounce them at once, if they cannot be sustained by a more thorough investigation.

Philadelphia, May 16th, 1857.

* At Professor Shepard's suggestion, a copy of his paper was sent to Dr. Genth, as soon as the sheet was printed.—Eds.

ART. XI.—*Notice of a Meteoric Stone which fell at Petersburg, Lincoln county, Tennessee, August 5th*, 1855; by CHARLES UPHAM SHEPARD.

A BRIEF account of this stone is contained in the Geological Reconnoissance of Tennessee by Prof. James M. Safford, the geologist of the State.* I shall first give the substance of his account; and then subjoin some observations of my own, derived from an examination of the entire specimen, which through the kindness of Prof. Safford, I have been permitted to make.

The particulars of the fall were communicated by the Rev. T. C. Blake of Cumberland University. The stone, which at first weighed three pounds, fell two miles west of Petersburg, in Lincoln county, at about half past three P. M., Aug. 5th, 1855, during, or just before, a severe rain-storm. Its fall was preceded by a loud report, resembling that of a large cannon, followed by four or five less reports. These were heard by many persons in the surrounding country. This stone was seen immediately after the reports, to fall to the ground. The observer of its fall was James B. Dooley, Esq. It approached him from the east, appearing while in progress, to be surrounded by a luminous halo two feet in diameter. It struck the ground only one hundred and fifty yards from him; and buried itself about eighteen inches in the soil. When first removed, it was still too hot to be handled. As first described by Prof. Safford, it had one edge broken, showing an ash-grey color within, varied by patches of white, yellowish and dark colored minerals; while its surface was invested with a very thin black and shining crust, as if it had been coated with pitch. One extremity of the stone has an irregular rhomboidal figure, measuring $2\frac{3}{4}$ by $2\frac{1}{2}$ inches. Placed upon this end, the body presents the form of a slightly oblique, and tolerably defined oblique rhombic prism, $4\frac{1}{2}$ inches long. The upper end however, is not well formed, but runs up to one side in a somewhat flattened edge. Three adjacent sides including the base are rough, being covered with cavities and pits; the others are smoother and rounded. The specimen acts upon the needle; fragments of it readily yield particles of nickeliferous iron, by trituration in a mortar. The specific gravity of the entire mass is 3·20.

The following are the results of an examination and analysis made upon fragments of the stone by Prof. J. L. Smith of the Medical Department of the University of Louisville. "The minerals present are pyroxene (the principal portion of the mass), olivine and orthoclase (disseminated), nickeliferous iron, (forming

* Published by G. C. Torbett and Co., State Printers, Nashville, Tenn., 1856.

about one half per cent of the mass.) In addition to these there are specks of a black, shining mineral, not yet examined. The general analysis is as follows:

| | |
|---|---|
| Silica, | 49·21 |
| Alumina, | 11·05 |
| Protox. iron, | 20·41 |
| Lime, | 9·01 |
| Magnesia, | 8·13 |
| Manganese, | ·04 |
| Iron, | ·50 |
| Nickel, | *trace.* |
| Phosphorus, | *trace.* |
| Sulphur, | ·06 |
| Soda, | ·83 |
| | 99·23 |

I find the glaze to resemble, in its thickness and general character, that of the Stannern stones; but in its high degree of glossiness, it approaches also the Juvenas meteorite. The figure is well described above, as being that of a somewhat oblique rhombic prism. It might perhaps be added, that at its upper or smaller end, there is a tendency to a replacement of the two obtuse angles, each by a single plane, thus producing a sort of dihedral summit, whose edge of course coincides with the longer diagonal of the base. The lateral planes, meeting under an obtuse angle, agree in being smooth, together with the replacing plane of the angle at the upper end of the obtuse edge. The corresponding planes, together with the base, possess a totally different character, being rough and deeply pitted. This is a property so general in meteorites, as obviously to depend upon a general cause; the nature of which however, it is difficult to conjecture. Sometimes the deeply pitted or undulating surface is confined to two sides, in place of extending to three or four; but it is nevertheless often visible upon at least one third of the general area; and occupies it, without interruption of patches of the smoother kind of surface. The edges of the uneven planes are less perfectly defined than of the other planes; and this is particularly true of the meeting of the two larger ones, in the present instance.

The heaviest end of this stone is of course towards its basal extremity. It is therefore natural to suppose, that its motion must have been with this end in advance. And it is curious to observe, that there exist a series of delicate wavy lines traversing the crust of the stone from its base, quite to its opposite smaller end, as if they had been produced from the friction of the atmosphere upon its liquified crust. Could the escape of

electricity have had any influence also in producing such an appearance? The fact of the marking however, is most obvious, whatever may have been the cause.

Viewed near by, the crust is seen to be somewhat variegated in color. Small specks of a yellowish brown, and more rarely, of a yellowish white color, interrupt very frequently the general pitchy hue of the glaze. These lighter colored portions are translucent; and are seen to arise from the character of the subjacent minerals, which have undergone fusion.

The fresh fracture has an ash-grey color, with a slight intermixture of pearl-grey, for the basis of the stone. Three-fifths of the stone may be said to have this tint. Diffused through this, occur rounded and polygonal patches (the largest half an inch in diameter, the smallest scarcely distinguishable by the naked eye) of a highly crystalline, snow-white mineral. The former of these minerals, I take to be anorthite, the latter is chladnite. The anorthite is often in four sided, nearly rectangular prismatic crystals, with blunted edges, and somewhat pitted faces. The largest of these are about one-quarter of an inch in thickness, while the smallest are less than half a rice-grain. Some of them are purplish-grey in color. Very distinct crystalline grains of green pyroxene, nearly a quarter of an inch in diameter are also visible, here and there, through the stone. They present one very distinct cleavage, like ordinary sahlite. In color, they vary from pistachio-green, to dark blackish grass-green. Olivine in grains of a light-yellowish green color and nearly transparent, is everywhere disseminated through the mass, even through the white patches of chladnite, where however, its color fades to a very pale, wine-yellow tint. The minute black, pitchy crystals were found to exhibit equilateral triangular faces, and to possess under the blowpipe the characteristic reactions of chromite. They are very numerous; and occur along with exceedingly fine grains of nickeliferous iron, in every portion of the mass. The pyrites, though proved by a treatment of the powdered stone with hydrochloric acid, to be present, is nevertheless not to be recognized even with a glass. Among the other constituents of the stone, I noticed a single crystal (apparently dodecahedral) of a hard, red, earthy mineral, closely resembling the substance I called garnet, in the Nobleboro (Maine) meteoric stone.

The stone breaks with rather more than the usual facility of meteoric stones. The specific gravity of fragments $=3{\cdot}23$. The nickeliferous iron, separated by the magnet, amounted to 2·5 p. c. The stone was then finely powdered; and on digestion with strong hydrochloric acid, readily suffered decomposition in the feldspathic part of its constitution, with the separation of silicic

acid.* The solution afforded the following constituents in the ratios annexed:

| | |
|---|---|
| Alumina, | 13·00 |
| Lime, | 4·00 |
| Protoxyd of iron, | 1·80 |
| Magnesia, | ·50 |

which coupled with the concurring mineralogical and blowpipe evidence of the character of the leading constituent of the stone, leave no doubt of its being true anorthite. The pyroxene, chladnite and olivine, afforded each, the usual blowpipe proofs of their agreement with those species, respectively.

The following may be taken as a tolerably close approximation to the mineral constitution of the Petersburg stone:—

| | | |
|---|---|---|
| Anorthite, | 82·0 | p. c. |
| Chladnite, | 9·0 | " |
| Olivine, | 5·0 | " |
| Pyroxene, | 1·0 | " |
| Nickeliferous iron, | 2·5 | " |
| Chromite and pyrites, | 0·5 | " |
| | 100· | |

Charleston, S. C., March 21, 1857.

---

## Art. XII.—*On the Separation of Magnesia and Lithia;* by J. W. Mallet, Ph.D.

[Concluded from vol. xxiii, p. 430.]

It having been found that the two bases under consideration could not be accurately separated by *ignition* as chlorids with oxyds of mercury, another experiment was made with the same reagent, carrying the heating no higher than 100° C. *Precipitated* oxyd of mercury was employed instead of the finely pulverized crystalline oxyd which had been used in the former experiments. The magnesia alone was quantitatively determined.

(1.) ·3463 grm. of pure MgO was dissolved in muriatic acid, mixed with about ·4000 grm. of LiCl in solution in water, and the mixture gradually evaporated to dryness over a steam-bath along with an excess of pure freshly precipitated oxyd of mercury. When the mass had become perfectly dry, it was again moistened with water, again dried at 100°, once more moistened, and a third time thoroughly dried. It was now treated with boiling water, the fluid filtered, and the insoluble matter remain-

* The silicic acid could not be separated from the undecomposed chladnite, olivine and pyroxene.

ing on the filter most thoroughly washed. This insoluble residue consisted mainly of magnesia and the red-brown oxychlorid of mercury (HgCl, 3HgO?), mixed with some free oxyd of mercury. It was cautiously ignited, the filter burnt, and the remaining magnesia weighed.

(2.) ·4890 grm. of MgO was mixed with about ·4000 grm. of LiCl, and treated in the same way as the above.

The results of these two experiments were as follows:

| | Magnesia. | |
|---|---|---|
| | Actually used. | Found. |
| (1.) - - - | ·3463 | ·2029 |
| (2.) - - - | ·4890 | ·1931 |

or but 58 and 39 per cent of the magnesia employed were obtained.

Hence it appears that chlorid of magnesium is far from being completely decomposed by oxyd of mercury after three evaporations therewith at 100°. This fact renders H. Rose's directions for the application of Berzelius's method for the separation of magnesia from the fixed alkalies at least doubtful. We are told in the Handwörterbuch d. Analyt. Chemie (Ausg. v. 1851, Bd. 2, p. 45,) to evaporate the mixture with oxyd of mercury to dryness, the temperature not being specified, and then to redissolve in water, filter, etc., the mercury being afterwards driven off from the alkaline chlorids and the magnesia separately.

Fresenius directs the mixed mass to be *ignited* before the resolution of the alkaline chlorid in water. The original paper of Berzelius I have not been able to refer to.

The other modes of separating lithia and magnesia—namely, the precipitation of the latter base by baryta water or by milk of lime, I have carefully tested, and find them both to succeed well.

Thus—(1.) ·9800 grm. of LiCl was dissolved in water, and mixed with the solution in muriatic acid of ·2545 grm. of MgO. (2.) ·4866 grm. of LiO, $SO_3$, and ·3004 grm. of MgO dissolved in dilute sulphuric acid were mixed together. To each of these mixtures an excess of baryta water was added, and, after boiling, the precipitated magnesia was filtered off and washed. Baryta having been removed from the filtrate by dilute sulphuric acid the solution of sulphate of lithia was evaporated to dryness, ignited and weighed.

The magnesia was redissolved in muriatic acid, baryta precipitated by sulphuric acid, and magnesia thrown down as ammoniacal phosphates, in which state it was weighed.

The results were

| | | Present. | Found. | | Present. | Found. |
|---|---|---|---|---|---|---|
| (1.) | LiCl | ·9800 | ·9829 | MgO | ·2545 | ·2533 |
| (2.) | LiO, $SO_3$ | ·4866 | ·4907 | MgO | ·3004 | ·2975 |

or, in exper. (1.) 100·30 p. c. of the LiCl and 99·53 p. c. of the MgO were obtained, and in exper. (2.) 100·84 p. c. of LiO, $SO_3$ and 99·03 p. c. of MgO.

Again—mixtures were made of (1.) ·8644 grm. of LiCl and ·1640 grm. of MgO (dissolved in HCl)—(2.) 2·5426 grm. of LiCl and ·8396 grm. of MgO—(3.) ·6906 grm. of LiO, $SO_3$—and ·3536 grm. of MgO (dissolved in $SO_3$)—(4.) about ·7000 grm. of LiCl and ·6741 grm. of MgO. Each of these solutions was boiled with milk of lime in excess, and filtered, the residue on the filter redissolved in muriatic acid, lime precipitated from the solutions of now separated magnesia and lithia by oxalate of ammonia, and, after filtration, the lithia determined as anhydrous sulphate and the magnesia as ammoniacal phosphates, with the following results:

| | | Present. | Found. | | Present. | Found. |
|---|---|---|---|---|---|---|
| (1.) | LiCl | ·8644 | ·8693 | MgO | ·1640 | ·1628 |
| (2.) | LiCl | 2·5426 | 2·5499 | MgO | ·8396 | ·8363 |
| (3.) | LiO, $SO_3$ | ·6906 | ·6920 | MgO | ·3536 | ·3499 |
| (4.) | LiCl | ∓·7000 | —— | MgO | ·6741 | ·6703 |

or the following per-centage proportions of the substance present were found:

| | | | | |
|---|---|---|---|---|
| (1.) | LiCl | 100·56 p. c. | and MgO | 99·27 p. c. |
| (2.) | LiCl | 100·29 " | " " | 99·61 " |
| (3.) | Li,O $SO_3$ | 100·20 " | " " | 98·95 " |
| (4.) | LiCl | —— " | " " | 99·43 " |

We thus find a constant small excess of lithia and small loss of magnesia. Owing to the facility with which both sulphate of baryta and oxalate of lime pass through the pores of even a very close filter, *traces* of these salts were found in the sulphate of lithia weighed, partly accounting for the slight excess in which the latter substance appears; but the errors for both bases determined are confined within so narrow limits, and the results compare so fairly with those obtained in other commonly employed processes of quantitative analysis, that these two methods for the separation of magnesia from lithia, may be looked upon as good and reliable. In cases where we have to deal with but small quantities of the bases, baryta water will be found the more convenient reagent, while on a larger scale, when we wish to keep the volume of liquid within moderate limits, and when the relative cost of baryta and lime requires consideration, the latter, used in the state of thin creamy mixture with water, is rather to be recommended.

# SCIENTIFIC INTELLIGENCE.

## I. CHEMISTRY AND PHYSICS.

1. *A new oxyd of Silicon.*—Wöhler has communicated to the Academy of Sciences a brief notice of a new oxyd and chlorid of silicon. While occupied with the study of the conducting power of aluminum for the galvanic current, Wöhler and Buff observed that when a plate of this metal is made the positive pole in a solution of chlorid of sodium, a gas is disengaged which takes fire spontaneously in the air. Supposing that the silicon contained in the aluminum had something to do with the phenomenon, the authors sought to prepare the gas by purely chemical means. By heating silicon to redness in a current of dry chlorhydric acid gas the acid was easily decomposed, hydrogen being evolved and a new chlorid of silicon produced. This is a fuming, very mobile liquid, more volatile than the ordinary chlorid, $SiCl_3$. It is decomposed by water into chlorhydric acid and a new oxyd of silicon. This latter is a white matter, slightly soluble in water, and very soluble in alkali, even in ammonia, disengaging hydrogen gas with effervescence, and becoming converted into silicic acid. Heated in the air it takes fire and burns with a very white light, disengaging hydrogen, which takes fire. The authors are studying the constitution of the new chlorid and oxyd.—*Comptes Rendus*, xliv, 834.

2. *On the artificial production of Glycerine.*—Wurtz has succeeded in preparing glycerine artificially from the tribromid of allyl, $C_6H_5Br_3$, which is obtained by the action of bromine upon the iodid of allyl, $C_6H_5I$, iodine being set free. The bromid is a heavy colorless liquid which at a temperature below 10° C. crystallizes in beautiful colorless prisms. By the action of this bromid dissolved in acetic acid upon acetate of silver an oily liquid was obtained boiling at 268° C., neutral, colorless, and heavier than water. This liquid is triacetine, $C_{18}H_{14}O_{12}$. By saponification with baryta-water, acetate of baryta and glycerine were formed. The latter was identified by its properties and by analysis.—*Comptes Rendus*, xliv, 780.

3. *Preparation and properties of Manganese.*—Brunner has prepared metallic manganese by the action of sodium upon fluorid of manganese. The materials are mixed and pressed together in a Hessian crucible, the mixture covered with a layer of chlorid of sodium and this with a layer of fluor spar in pieces of the size of a pea. The crucible is covered, placed in a forge and heated gently. The reduction takes place before the crucible becomes red hot, and is indicated by a hissing noise and yellow flame. The heat is then raised nearly to whiteness and the whole is allowed to cool slowly. The metal is found as a fused mass. Manganese as thus prepared possesses properties very different from those usually attributed to this metal. Its color is that of cast iron; it is very brittle and extremely hard, scratching the best tempered steel. It takes the most perfect polish and does not change in moist air at common temperatures: polished specimens were kept two months in the laboratory without change. The density of this manganese varied from 7·138 to 7·206. It is not attracted by the magnet and has no action on the magnetic

needle. Acids attack it strongly. From its extreme hardness manganese appears well adapted to various purposes. A fragment with a sharp edge will serve to cut glass like diamond. The metal may be cast in moulds like iron, and the high polish which it assumes may render it available for the mirrors of telescopes, etc. In conclusion the author directs attention to the probability that manganese will form useful alloys.—*Comptes Rendus*, xliv, 630.

4. *On crystallized Chromium and its alloys.*—At the same sitting of the Academy at which Brunner's memoir was read, Frémy communicated a note on the preparation of manganese and chromium by a somewhat different process, namely, by passing the vapor of sodium over the anhydrous chlorids. The decomposition takes place in a porcelain tube heated to redness, the vapor of sodium being conveyed by a current of hydrogen. Chromium as thus obtained presents itself in the form of small cubic crystals, which are very hard and brilliant, and which resist the action of the strongest acid, and even of aqua-regia. The alloy of chromium and iron crystallizes in long needles and scratches the hardest bodies, even tempered steel. The author finds that the sesquioxyd of chromium may easily be fused at a forge heat and yields a very hard black crystalline mass which may perhaps find useful applications.

5. *On some general methods of preparing the elements.*—H. Sainte Claire Deville, in connection with the communications of Brunner and Frémy, has offered some interesting remarks upon the subject which is now attracting so much attention in France and Germany, the preparation of the rarer metals. Deville is of opinion that the best mode of preparation consists in igniting the oxyd with carbon, taking care to employ an excess of oxyd. It is however an indispensable precaution to fuse the metal in a crucible of lime or magnesia. Crucibles of clay, porcelain, &c., are like borax partially reduced by many metals and even by platinum. The silicon produced considerably increases the hardness and fusibility of the metal. In a crucible of lime the oxyd of chromium or manganese in excess is absorbed by the lime, forming a chromite or manganite which fuses with great difficulty, but which removes from the metal all traces of carbon and silicon. The fusibility of the metal diminishes as their purity increases, and the author found chromium less fusible than platinum. Deville remarks that manganese, as prepared by Brunner's method, may still contain carbon. Sodium prepared from the carbonate always contains more carbon, and moreover, from its porosity it frequently retains naphtha, which leaves a carbonaceous residue when heated. The employment of Hessian crucibles is also objectionable, as silica is easily reduced by sodium, especially in the presence of the fluorids. In this manner the author explains the differences between Brunner's manganese and that prepared by himself, which is less fusible than iron and decomposes water at ordinary temperatures. The employment of sodium, on the other hand, presents great advantages when we wish to obtain an element in a crystallized state. In this case the sodium may often be replaced by aluminum, as for example, in preparing silicon, titanium, zirconium, and boron. In the case of the sesquichlorids of zirconium, aluminum or chromium, it is always well to make the sodium react upon the double chlorids which these bodies form with chlorid of

sodium. The process should be conducted in a crucible of alumina which is to be heated to redness before putting in the mixture of chlorids. In the case of the fusible metals it is well to add to the whole a little double chlorid of sodium and potassium. Deville and Damour are now applying this process to the cerium metals. Sodium attacks porcelain at a low red heat with such energy that there is always danger of introducing silicon into metals reduced in such vessels. This perhaps explains the difference between the properties of chromium as prepared by Frémy and that prepared by Deville and Bunsen, the latter being readily soluble in chlorhydric acid giving a blue solution of the protochlorid. In conclusion, the author again recommends the employment of crucibles of lime which refine the metals fused in them. The platinum metals fused in such crucibles present properties very different from those usually attributed to them, the lime serving to deprive them of osmium and silicon.—*Comptes Rendus*, xliv, 673, *March 30th*, 1857.

6. *On the amids of the monobasic acids.*—Cahours has found that the amids of benzoic, toluic, and anisic acids obtained by reducing nitro-benzoic, &c. acids by means of sulphydric acid or acetate of iron, and become known as benzamic acid, &c., behave like bases as well as like acids, and from classes of well defined salts. The chlorhydrates of these bases closely resemble those of the alkaloids and from well crystallized chlorplatinates. Glycocoll forms precisely similar compounds. The author points out the fact that glycocoll bears the same relation to a mononitroacetic acid which benzamid does to a nitrobenzoic acid, since we have

$$C_{14}H_5(NO_4)O_4+6HS=6S+4HO+C_{14}H_7NO_4$$
$$C_4H_3(NO_4)O_4+6HS=6S+4HO+C_4H_5NO_4.$$

As chlorid of benzoyl by acting on glycocoll-zinc yields hippuric acid, Cahours has found that the chlorid of cumyl and anisyl yield analogous products by their action upon glycocoll-silver. The products have the formulas

| | |
|---|---|
| Cuminuric acid, | $C_{24}H_{15}NO_6$ |
| Anisuric acid, | $C_{20}H_{11}NO_8$. |

As might be expected, the same chlorids by acting upon benzamate of silver, &c., yield new acids also analogous to hippuric acid. From these facts it is clear that there exists a strong analogy between the *amic* acids and glycosin, alanin, leucin, &c.—*Comptes Rendus*, xliv, 567.

7. *On a new series of organo-thionic acids.*—Hobson has described a new acid obtained by the action of sulphurous acid upon zinc-ethyl, and named by him ethylo-trithionic acid. When sulphurous acid gas is brought into contact with zinc-ethyl a rapid absorption takes place with the evolution of much heat, and the whole contents of the flask are converted gradually into a white mass of minute crystals. These form the zinc salt of the new acid and have the formula as the author writes it:

$$ZnO, S_3\left\{\begin{matrix}C_4H_5\\O_5\end{matrix}\right\}+HO.$$

The formation of the acid is easily explained by the equation

$$Zn.C_4H_5+3SO_2=ZnO+S_3(C_4H_5)O_5.$$

Hobson considers the new acid as formed by the replacement of one equivalent of oxygen in three of sulphurous acid by one of ethyl. The acid yields colorless and crystalline salts with various bases. Sulphurous acid forms a similar compound with zinc-methyl, and doubtless there exists a series of thionic acids homologous with that described by Hobson. —*Quarterly Journal of the Chemical Society, April*, 1857, 55. W. G.

8. *Note on Ritchie's improved Ruhmkorff's Apparatus ;* by the author. —Since writing my paper (p. 45) I have constructed a helix in which the plane of the strata of wires is perpendicular to the tube, insulated as before. With one of the same length of wire as the largest one before mentioned,—throwing a spark, with six cells, six inches,—I have used a battery of eighteen cells, (Bunsen's); but by using a battery of three series of six cells (that is, an *intensity* of six, and quantity of three), a very voluminous spark was obtained; as the action soon became feeble, I took the secondary coil from the glass cylinder and found that the current had *passed through the glass* near each end of the coil, forming a circuit through the primary wire; two minute holes, of a hair's breadth, from one-tenth to one-eighth inch diameter, were drilled through, but the glass was *not fractured ;* it also passed through several thicknesses of vulcanized rubber. The helix was uninjured, proving the insulation obtained by the mode of winding it. A more perfect insulation between the helices is readily made; and I now use a tube of gutta percha over the glass. With powerful batteries the condenser of varnished paper is not sufficient, as the current passes entirely through, and with such I use oiled silk. I have put several condensers in the same instrument, connecting each by turning a screw, so that either or all can be used. Varied and beautiful effects are produced, particularly in vacuo, by using different amounts of surface of condenser.

Boston, June 10th, 1857.

9. *Silica and Alumina in the ashes of Lycopodium.*—The ashes of three Lycopodiums afforded F. H. Grafen (Ann. Ch. Pharm. C., 297), the following results:

| | Silica. | Alumina. |
|---|---|---|
| 1. Lycopodium chamæcyparissus, | 13 | 54 |
| 2. L. clavatum, - - - - - | 14 | 27 |
| 3. L. denticulatum, - - - - | 42 | 2 |

## II. MINERALOGY AND GEOLOGY.

1. *Supplement to the Fifth Edition of a Manual of Elementary Geology ;* by Sir CHARLES LYELL. 2d edition revised. 38 pp., 8vo. London: 1857.—This supplement contains chapters on the following topics:

(1.) British Pliocene strata,—including observations on change of climate in the pliocene epoch,—on fossil mammalia in the Thames valley—on the fossil musk-buffalo in the drift near London and near Berlin.

(2.) Where to draw the line between the Miocene and Eocene; in which the Nebraska tertiary is arranged in the lower miocene.

(3.) Miocene Fauna of the Sewalik Hills.

(4.) Denudation of the Wealden.

(5.) New Fossil Mammalia from the Purbeck or Upper Oolitic strata in Dorsetshire.

(6). Discovery of Mammalian Remains in rocks of high antiquity in North Carolina, United States.

(7.) Upper Trias of the Eastern Alps.

(8.) On the supposed evidence of Phænogamous plants (not Gymnosperms) in the Coal Formation.

(9.) On Silurian and Cambrian Rocks, and M. Barrande's theory of Colonies.

The mammalian remains of the United States are from the discoveries of Prof. Emmons in North Carolina. The fossils are from the Red Sandstone—of the same formation with the sandstone of the Connecticut valley, whose age is not yet made out with certainty, although probably as recent as the lower Jurassic.

The fossil oolitic mammalia from the Purbeck beds are among the most interesting discoveries of recent times.

The fifth edition of the "Manual" contains notices of six species of mammals, the *Phascolotherium*, *Amphitherium*, and *Stereognathus* of Stonesfield, the *Microlestes* of the Upper Trias, the *Spalacotherium* of Purbeck, and a lower jaw of another undetermined species.

The Purbeck beds, especially the "dirt bed" of the middle Purbeck, seemed to promise other discoveries, and the search has proved successful. This bed averages five inches thick, and contains remains of insects and freshwater shells (Paludina, Planorbis, Cyclas). In three weeks exploration by Mr. Beckles, five or six new species of three or four new genera, were found in an area forty feet by ten, the size varying from that of a mole to that of a hedgehog; and besides there was the entire skeleton of a crocodile, the shell of a freshwater tortoise, and remains of some smaller reptiles. Mr. Brodie had previously made collections from the same bed near Swanage, and among them were the lower jaws of three mammalian species and the upper portion of a skull. For one lower jaw on the same slab with the skull, having eight molars, a canine and an incisor, Owen has proposed the generic name *Triconodon;* the animal was nearly as large as a hedgehog. Another species of *Triconodon*, a third larger, has been detected among the specimens obtained by Mr. Beckles. Another jaw is related to *Amphitherium*, though generically distinct. The *Triconodon*, according to Dr. Owen, is allied to the *Phascolotherium* and *Thylacotherium;* and he states that all these genera belonged "to the same natural group of an Insectivorous and very probably Marsupial family."

There are also among the fossils, the jaws of two other animals, which Dr. Falconer has named *Plagiaulax Becklesii*, and *Plagiaulax minor;* they are most nearly related to the living kangaroo rat (genus *Hypsiprymnus*), of which ten species are known. The single præmolar is marked somewhat diagonally with *seven* sharp parallel ridges, crossing the summit, and the modern species have also *seven* ridges, differing only in being placed transversely. *P. Becklesii*, the largest species, was about as large as the English squirrel, and the other not over half this in length. The specimen of the latter contains two back molars which are exceedingly like those of the Triassic *Microlestes*, showing that the Microlestes was a closely related genus.

Professor Owen now regards the *Spalacotherium* as probably marsupial. Part of the cranium of another mammal has been disinterred, and

Dr. Falconer has remarked a relation to the insectivorous *Ericulus* of Madagascar, and from the general bearing of the evidence, it is thought that it was not marsupial. "Specimens are arriving weekly from Mr. Beckles, and we may expect a great addition to the number of individuals as well as an increase in the number of species. To gain access to these treasures he has already at his own cost removed nearly 3000 tons weight of stone overlying the dirt bed."

The facts thus far ascertained, prove the existence of about fourteen species of mammalia in the Middle Purbeck. They belong to eight or nine genera. All have been obtained from an area less than 500 square yards in extent, and from a single stratum but a few inches thick.

2. *Report on the Geological Survey of South Carolina:* being the First Annual Report to the General Assembly of South Carolina, embracing the Progress of the Survey during the year 1856, with plates and maps; by Oscar M. Lieber, Mineralogical, Geological and Agricultural Surveyor of South Carolina, etc. 136 pp., 8vo. Columbia, S. C.—This First Annual Geological Report by Mr. Lieber treats especially of the Chesterfield, Lancaster, Chester and York Districts. The region is to a great extent characterized by crystalline or metamorphic rocks, among which the gold veins or mines occur. The author has a field of great interest and has taken hold of it with energy and success. There is no department in American geology requiring more study than the metamorphic rocks of the Atlantic States, and especially those of the South. The descriptions and handsome maps of Mr. Lieber's report throw much light on the subject, and when the survey is completed—which we trust it will be without interruption—the doubts as to the age of the metamorphic rocks and the period of metamorphism, must certainly be much lessened if not wholly removed. The structure of the gold veins, and their true relations to the containing rocks, their resources, and the value and nature of copper and other mines in the states, are additional topics of great importance, which Mr. Lieber has begun to elucidate.

The *Itacolumite* rock, a peculiar arenaceous rock occurring in the gold region of Brazil and the Urals as well as Carolina, is described with much interesting detail; and since the publication of his Report, Mr. Lieber has added (as we learn by letter) the important discovery of the passage of the itacolumite into a true sandstone or even a conglomerate, proving its original sedimentary origin.

Associated with itacolumite occurs a slaty rock made up largely of specular iron. We cite the following observations on this "specular schist," the siderocriste, or eisenglimmerschiefer of European authors.

"This rock, which is so exceedingly rare—for the only localities hitherto described or mentioned are in Brazil, Marmoras and Provence—appears in beds intercalated between the talcose slates. As true specular schist, the Bird bank or specular ore bank can alone be named. This is seen at various points between the western declivity of King's mountain and the southern lime outcrop, extending thence southwestward to the two ranges of hills, which bound the Dolittle (or Dearlittle) Creek—the Dolittle and Silver mountains. On the former of these, the outcrop is wider than at any other point observed; for they have already quarried

across it, thirty-five or forty feet, without meeting any interruption. Indeed, the whole of the hill consists of alternating beds of quartz, talcose and specular schists. The greatest thickness of the latter is between the itacolumite and talcose slate. The strike of these beds is N. 41° E., the dip 64½ S., 49° E., but owing to folds of the rocks, some quartz beds strike N. 5° E., and some of the talcose slate N. 11° E., both being vertical in dip. The interrupted extension of the beds of the specular slate northwest and southeast at this point is about half a mile, though in its northeastern prolongation it gradually becomes narrower, until east of the place of A. Harding, Esq., it finally gives out.

On the Dolittle mountains we find this remarkable rock not only most perfectly developed as regards extent, but also most strongly marked in its peculiar petrographic characters. Here it presents so great a similarity with some micaceous schists, that, at first sight, few would suppose it to be anything else. In color it is steel-grey, but its crimson streak, when scratched, distinguishes it from mica-slate, to which it possesses a resemblance in the laminated or scaly nature of the individual parts of the iron glance. Sometimes, especially farther north, this feature disappears to a considerable extent, and the rock becomes less schistose and granular, owing to the shape of the minute crystals of the iron ore. In these cases talc generally enters more conspicuously into the composition of the rock, and, owing to the presence of a small admixture of magnetite, it becomes slightly magnetic. As an ore this rock is greatly valued at the furnaces, though not used to any extent at the bloomeries.

Where atmospheric action has been able to affect the rock, the specular iron (anhydrous peroxyd) is converted into earthy hematite (hydrated peroxyd). This generally forms as a crust and the mass contains harder nuclei.

The magnetic iron beds of this region seem to be in part synonymous with the *itabirite* of Eschwege. We have indeed the true itabirite, that is an itacolumite in which the talc is replaced by magnetic iron, although generally in South Carolina the quartz is present in less quantity, and the accompanying talc greatly increased in amount to that which, according to description, seems to be the case at the Peak of Itabira, the Sierra-da-Piedada and other Brazilian localities. With us the rock essentially consists of talc (or chlorite) and crystals of magnetite, the former being the matrix of the latter, while talcose strata less admixed with magnetic iron, are intercalated between the others. These do not affect the needle, while the former are highly polaric. Wherever I have examined beds of this rock, as for instance at the Lee and Parker bank and the ore beds of the Swedish Iron Manufacturing Company in the corner of Union (both of which are outcrops of the same bed), dikes of melaphyre or diorite appeared in the immediate vicinity; so that it is not impossible, that the magnetite may have resulted from a partial reduction of the peroxyd of iron of the specular schist to a protoxyd.

This rock also occurs at the junction of the itacolumite and talcose slate, and, therefore, gives additional reason for regarding it as a continuation of the specular beds, although separated from it superficially by the itacolumite. At the Lee and Parker ore bank it is immediately underlaid by a barytic vein, the width of which has not yet been determined. The

heavy spar, likewise, appears as streaks or intercalations, and the vein also cuts off the ore bed occasionally, and may, perhaps, have been the means of the introduction of that sulphur, which has converted the magnetic bed into a pyritiferous one at a depth rarely exceeding sixty feet. Accessory minerals which are found there are:—mesotype, hyalite, quartz, chlorite, very pure talc, asbestus, staurotide, and, owing to the decomposition of the pyrites, sulphate of iron.

The strike of the bed at the Lee and Parker bank is N. 47° E., its dip 60° S. 43° E. The bed continues, with one or two apparent interruptions, and crosses to the east of the summit of King's Mountain in North Carolina. That this interruption is a seeming one only and altogether confined to the surface, is decisively evinced by a most singular fact. When Briggs sank a deep pump shaft at his gold mine in North Carolina some years ago, the works at the Parker as well as the Lee bank, at least thirteen or fourteen miles distant, were entirely drained, filling again when he stopped his pumps and draining a second time when Commodore Stockton put them in operation again. They thus form, in their southwestern prolongation into our State, a saddle-shaped alteration in dip, which admits of an easy explanation in the folds of the rocks, of which this region is constituted.

As an ore, this catawbarite has long been appreciated and will continue so, until the destruction of the forest growth—no remedy for which has hitherto been attempted—will render the charcoal used too expensive to prosecute the manufacture of iron with advantage. This fatal result can be avoided only by a thoroughly organized cultivation of woods.

The ores of this region yield a steel which is probably unrivalled even by that derived from Swedish iron, and their fame has already extended to England."

3. *New Fossil Fishes from the Devonian Rocks of Ohio;* by J. S. NEWBERRY, M.D. (Bulletin of the National Institute.)—Dr. Newberry here describes two species of fossil fishes of the new genus *Agassichthus* Newberry, two of *Onychodus*, Newberry, one of *Psammodus*, three of *Machæracanthus*, Newberry, and four of *Oracanthus.* The genus *Agassichthys* and its species, which were of very large size, are described as follows:

AGASSICHTHYS, Newb. Cœlacanth ganoids of large size. Cranial surface covered with thick-set stellate tubercles, either in lines radiating from various centres, or without regular arrangement. Cranium composed of large plates, united by double sutures which are nearly concealed by the dermal tubercles of the superior surface. Eye orbits conspicuous, and included in the orbital plates. Teeth in two rows, conical, curved, not plicated at base. Scales obscurely rounded; the exposed portion ornamented with small tubercles and fine divergent raised lines; the covered portion marked with lines of growth, and finely reticulated, as in *Rhizodus, Glyptolepis*, &c.

(1.) *Agassichthys Manni*, N. The species to which I have given this name resembles in its general appearance Von Meyer's *P. Agassizii*, and may possibly prove to be identical with it; but in Von Meyer's specimen no characters remain except the partial outline of some of the plates: in this character his figure and my specimens differ in the outline of the nasal plate. In his specimen it is broader, and the posterior angle greater.

The crania which I have are from 6 to 9 inches in length, and 4·3 to 6·6 inches in breadth; the normal breadth being probably relatively less than either of these measurements; all the crania having suffered a greater or less amount of compression and expansion. A transverse section of the central or posterior part of the cranium forms an arch from $1\frac{1}{2}$ to 2 inches in height; the longitudinal profile exhibiting a depression of the nasal extremity precisely the reverse of that shown in von Meyer's figure, where the occipital plate is depressed by a distortion of the specimen. The length of the nasal plate is a little less than that of the occipital, and the angle formed at its posterior extremity is of 32°. The borders of the cranial plates, with the exception of the nasal, exhibit no absolutely straight lines, but all are more or less curved.

(2.) *Agassichthys Sullivanti*, N. Another species scarcely less common in the Cliff limestone of Ohio I have called by this name; portions of the cranium having been obtained by Joseph Sullivant, Esq., of Columbus, Ohio, from his quarries in the vicinity of that city, as early as 1836.

This species is larger than the last, the crania having a length of 10 to 12 inches or more, and fragments indicate a considerably greater size. The relative breadth of the cranium was greater than in *A. Manni*. In a fine specimen sent me by Dr. Mann, which has a length of 10 inches, the greatest breadth is $8\frac{1}{2}$ inches. The arch of the transverse section is 2 inches in height. The longitudinal profile forms a nearly uniform inclined plane from occiput to nose. The borders of the cranial scutcheons are generally right lines, giving to the mosaic pattern formed by them a more geometric appearance than in the last species. The nasal plate is relatively much broader, and its posterior angle less acute (53°).

A fortunate fracture of this specimen shows that the form of the cerebral cavity is as perfectly preserved as that of the cranial plates. Both species are from Columbus, Milford and Sandusky, Ohio.

The following are descriptions of the new genera Onychodus and Machæracanthus:—

"ONYCHODUS, Newb. Among the fossils sent me by Dr. Mann are two specimens of what in his notes he very significantly calls a "claw jaw;" of which I have seen a third and very beautiful specimen in the hands of Prof. Hopkins, of Geneva, N. Y.

This fossil consists of a series of remarkably acute and curved teeth, closely set on a common base, all curving in the same direction, and apparently erectile. The detached teeth are frequently found in the Cliff limestone from 1 inch to 2 inches in length. They are much curved, have a circular section towards the summit, are somewhat compressed below, and expand at base into several prominent roots, of which the most conspicuous are on the side towards which the point is curved. These teeth have a central cavity extending nearly to the summit: this cavity is surrounded by dentine, simple in structure; and the whole is covered by a layer of smooth and polished enamel without striæ or ornament of any kind."

"MACHÆRACANTHUS, Newb. Spines often of large size, flattened, curved, ancipital, unsymmetrical; dextral and sinistral edges and point generally acute; base somewhat narrowed, losing the markings of the

upper part; termination rough and irregular. Central cavity large, running through nearly the entire length of the spine. Microscopic structure that of very dense ivory-like bone; external surface covered with a thin coating of enamel.

These spines are, I think, the fin-rays of placoid fishes, but exhibit a character not shown in any other known living or fossil genus, that is, their want of symmetry. They are in pairs, or, at least, are rights and lefts. Spines of this character were collected many years since by Joseph Sullivant, Esq., of Columbus, Ohio, in his quarries in the upper part of the Cliff limestone near that city. A specimen from that locality was exhibted by Mr. Sullivant at the Cleveland meeting of the American Association. Since then, beautiful specimens of one species have been obtained from the same geological horizon in New York, by Prof. Hopkins, figured in the Proceedings of the eighth meeting of the American Association.

Prof. H. is disposed to regard this as the spine of a crustacean; but its form as well as microscopic structure seem to me to prove it decidedly ichthyic.

If it were any portion of the exoskeleton of a crustacean, it should be tubular throughout, or have an articulation at its proximal extremity, neither of which is true.

It has every appearance of having been planted in the integuments without articulation, precisely as are all the dorsal spines of placoid fishes. We might suppose these fossils to be the first rays of pectoral fins, but in all fishes with which I am acquainted, the pectoral spines are articulated to the thoracic arch.

My convictions are that they were worn side by side upon the superior median line, either placed far back, as in *Trygon*, or farther forward, as in *Chimaera*, *Spinax*, *Cestracion*, &c. In none of these are there double spines, but in *Trygon* the spines of the tail are closely approximated, and it is very probable that such was the arrangement of our fossils."

4. *Report on the Economical Geology of the route of the Ashtabula and New Lisbon Railroad;* by J. S. Newberry, M.D. Made Nov. 1856. Cleveland, Ohio: 1857.—This Report, which is mainly economical in its aim, contains important geological information on the coal region, and a map and section of the country between Erie and Hudson, south of Lake Erie.

5. *Descriptions of New Fossil Species of Mollusca*, collected by Dr. F. V. Hayden, in Nebraska Territory: together with a complete catalogue of all the remains of Invertebrata hitherto described and identified from the Cretaceous and Tertiary Formations of that region; by F. B. Meek and F. V. Hayden, M.D. pp. 24.—This is the third paper of these two gentlemen, who have shown themselves so intelligent and successful in the investigation of the Nebraska fossil mollusca. All the papers have been published by the Academy of Natural Sciences at Philadelphia, and have thrown much light on the cretaceous and tertiary formations of that great territory. The last paper possesses even higher interest than the two preceding. Comparing the fossils collected in various sections with those of Nebraska, they show the parallelism of the Cretaceous formations of New Jersey, Alabama, &c. with that of Nebraska, the following

fossils being found in all, viz. "Ammonites placenta, Scaphites Conradi, Baculites ovatus, Nautilus DeKayi, &c." This identification is first announced by Messrs. Meek and Hayden. It is also shown that Inoceramus problematicus, found in Nebraska, is obtained also in Kansas, also in lat. 39°, lon. 98°, and farther towards the Rocky Mts. by Col. Fremont, and a shell considered the same, by Roemer in Texas: and that Ostrea congesta, so distinct in Nebraska, was found by Marcou and Galisteo between Fort Smith and Santa Fe. The cretaceous formation has a great extension at the west and south. The paper speaks for itself.

C. DEWEY.

6. *Proportion of Bivalves of different Geological Ages.*—H. G. Bronn gives the following table in an article on this subject in Leonh. u. Bronn's Jahrbuch, 1856, p. 656.—

| | Total number of species. | Brachiopods. Species. | Brachiopods. Proportion. | Lamellibranchiates with entire pallium. Species. | Lamellibranchiates with entire pallium. Proport'n. | Lamellibranchiates with sinus in pallium. Species. | Lamellibranchiates with sinus in pallium. Propor. |
|---|---|---|---|---|---|---|---|
| Living, | 2670 | 60 | =0·02 | 1480 | =0·55 | 1130 | =0·43 |
| Cænozoic, | 2497 | 52 | =0·02 | 1555 | =0·62 | 890 | =0·36 |
| Mesozoic, | 3447 | 371 | =0·11 | 2358 | =0·68 | 718 | =0·21 |
| Palæozoic, | 2021 | 1109 | =0·50 | 799 | =0·40 | 113 | =0·10 |

The column "proportion" gives the ratio to the total number of species. The cænozoic includes the Tertiary and Post-tertiary; the mesozoic, the formations below down to the Permian, and the Palæozoic the remaining below this limit.

The integripallial bivalves were most numerous in the mesozoic. Dividing them into the Pleuroconchæ (having unequal valves) and Orthoconchæ (equal valves), there are according to Bronn's Lethæa Geognostica,

| | Total. | Pleuroconchæ. | Orthoconchæ. |
|---|---|---|---|
| Living, | 1480 | 330=0·23 | 1180=0·77 |
| Cænozoic, | 1555 | 575=0·27 | 980=0·63 |
| Mesozoic, | 2358 | 1181=0·50 | 1177=0·50 |
| Palæozoic, | 799 | 299=0·37 | 500=0·63 |

There is no doubt that the Brachiopods are inferior to the other Bivalves, and also that the Integripallials are inferior to the Sinupallials.

7. *Slaty Cleavage.*—The view of Mr. Sharpe, presented to the Geological Society of London in 1847, that slaty cleavage is owing simply to pressure and is at right angles to the line of force, has been established by various facts brought forward by Mr. J. Tyndall. (Phil. Mag. [4], xii, 35). He shows that a fine clay or almost any impalpable material when subjected to pressure and at the same time allowed to spread laterally, takes a laminated structure. White lead, wax, and even cheese are among the substances which have afforded him evidence on this point. He attributes the effect to the small inequalities which exist in the texture of substances of all kinds. Under pressure the mass yields and spreads out, and the little nodules become converted into laminæ separated from each other by surfaces of weak cohesion, and thus the mass becomes cleavable. The air cavities or fissures also spread out thin under the pressure and aid in producing the cleavage: for even dried pipe-clay shows such cavities in great numbers, many too small to be seen without a magnifier.

Mr. H. C. Sorby had before attributed the cleavage to the effect of such lateral pressure on all the grains or pebbles in the rock, the force making the particles whether of mica or any stones to place their larger diameters in the plane at right angles to the direction of the pressure, that is in the plane of cleavage. He had appealed to facts in the slates of Wales, showing that where mica scales were present, they had this position. This cause may contribute to produce lamination, though not appearing to be necessary to the result.

In the Philosophical Magazine for December last, Rev. S. Haughton gives the results of some calculations to ascertain the amount of the pressure which was exerted in cases of the production of slaty cleavage, using as data the degree of distortion or compression of fossils.

8. *The genus Palæotrochis of Emmons, instituted as a genus of fossil corals.*—We have received a note from Prof. Emmons urging several reasons for sustaining his genus Palæotrochis, and against the view of its being a quartz concretion. The main point presented is the fact of its form—a double cone with striated sides, the striæ at right angles to the common base of the cones.

## III. BOTANY AND ZOOLOGY.

1. *Introduction to Cryptogamic Botany;* by the Rev. J. M. Berkeley, M.A., F.L.S. With 127 illustrations on wood, drawn by the author. London: H. Bailliere, 1857, pp. 604, 8vo.—This is the first original work of the kind that has been published in the English language. Its only predecessor, the English translation of Sprengel's Introduction to the Study of Cryptogamic Plants, appeared half a century ago, and its last edition in the year 1819. A comparison of the two books would be curious enough, so great has been the advance in our knowledge of the lower orders of plants during the interval, and especially within the last twenty years.

A work of this kind has long been a desideratum, and before all others would Mr. Berkeley be looked to, as best qualified to supply it. No British, and probably no foreign botanist, except Dr. Montagne, has so extensive and so accurate an acquaintance with the whole range of the lower Cryptogamous orders, and especially with Mycology. The work likewise indicates a good knowledge of Phænogamous botany, and discusses some important general questions with more than ordinary ability and breadth of view. As might be expected, the book before us is an excellent one, full of original observations, indispensable to the Cryptogamous student who cannot command a considerable library, and highly interesting to the general botanist. As respects the subject-matter, we can well believe the author's statement, that "an incredible amount of labor has been bestowed upon its preparation, in the examination of herbaria, the consultation of authorities, and the verification of facts." It is much to be regretted, candor compels us to add, that some part of this labor was not bestowed upon the arrangement and the style, which, considering the position of the accomplished author, are careless and faulty to an 'incredible' degree. The mere want of arrangement, although a serious defect in an elementary work, is not the worst of faults; and it is rather refreshing to meet with admirable and original observations in unexpected places.

What we most complain of, is the lack of ordinary attention to the structure of sentences, which renders the perusal of the earlier portion of the book a positive discomfort, and we fear, may sometimes prevent the tyro from apprehending the author's meaning. Nor will the use of the verb "to assist" in the French sense, help the mere English student much in his endeavors to bring the sprawling members of a heterogeneous sentence into intelligible order. Nor will he readily understand how in the high groups of Cycads, there can be "a *foreshadowing* of structures to be met with in a different and *inferior* series." (p. 54).

The preliminary observations and the chapter on Cryptogams in general deal with a high order of topics, some of them perhaps of too special a character for the beginner, unless he be supposed to be already an adept in Phænogamous botany; such questions as the difference between affinity and analogy, and between analogy and homology in organs; the rank of Coniferæ in the natural system; the limitation of the groups which we call classes, &c., as to whether they are absolute or blended in nature, &c., being incidentally but ably discussed, some of them in considerable detail. Mr. Berkeley evidently doubts if there be any clear demarcation between the animal and vegetable kingdoms,—at which we do not wonder:—while he is unable anywhere "to trace any close connection between Phænogams and Cryptogams," and is inclined to think Endogens and Exogens equally distinct,—which we are hardly disposed to object to;—but the two propositions together make a singular paradox. After all, how are differences of this sort to be measured and compared in the organic world? As to *Coniferæ* and other Gymnosperms, while we willingly allow that there is no affinity, and even perhaps no close analogy, between them and the higher Cryptogams, and regard them as genuine Dicotyledoneæ-Exogenæ, we are not ready to subscribe to the doctrine that the extreme simplification of their flowers and the direct impregnation of their naked ovules are not indications of low rank in their class. But this is not the place to discuss this vexed question.

If it is really "the best opinion that *Podostemaceæ* are reduced *Lentibulariæ*," then 'bad is the best,' surely. Not only is the embryo of *Nymphæa* "when properly understood, as distinctly dicotyledonous as in any other plant," but we do not see how it can possibly be understood in any other way. It is not clear to us that "no affinity is more sure than that between Cactus and Ribes." "The degree of volition, if such it may be called [in spermatozoids and zoospores] is extremely low, and may be unattended with any consciousness." (p. 85.) *May be*, indeed! Is consciousness a universal attribute even of animal life? Does the author suppose that the lowest animals, even that any animal destitute of a distinct brain, leads a conscious existence?

We have touched upon some of these incidental points as they attracted our notice, and have no space left in which to speak of the main body and general merits of the work. Distributing the Cryptogamous orders into *Thallogens* and *Acrogens*, and the former into two alliances, *Algales* and *Mycetales*, the latter including the *Lichenes* as well as the *Fungi*, the author devotes 150 pages to the general structure and systematic arrangement of the *Algales*, and 185 to the *Fungales*. Upon this, the principal staple and the most important part of the work, it would be

presumptuous for us to offer any criticism.* It appears to offer the student just the information he needs, and in an authentic and interesting form. The same may doubtless be said of the Acrogens. which are more briefly treated, its three alliances, *Characeales*, *Muscales*, and *Filicales* together occupying only about 130 pages. The book belongs to Bailliere's series of *Standard Scientific Works*, and will doubtless maintain a distinguished place, undergoing successive revisals as new editions are called for. A. G.

2. *Witterung und Wachsthum, oder Grundzüge der Pflanzenklimatologie* (i. e. *Weather and Growth, or Elements of Climatology as affecting Plants*); by H. Hoffmann, M.D., etc., Professor of Botany in Giessen. Leipsic: 1857. pp. 583, 8vo.—The first or special part contains: 1. An abstract of very detailed meteorological observations made at Giessen through the year 1854, embracing all the ordinary elements of climate; 2. Observations on growth, being a very detailed and elaborate study of the development of the buds, leaves, stems, flowers, &c. of thirteen common and well-chosen plants, under the given circumstances of climate. This is illustrated by a large folded plate, exhibiting in curves (printed in colors) the daily development of these thirteen plants, or of their leaves, stems, blossoms, &c. The second or general part occupies the rest of the volume, and considers in great detail the effect of the principal meteorological conditions upon the growth of plants. What the principal conclusions are, it is not easy to say, for want of a summary, which the author could readily have given: they are with difficulty to be eliminated by the reader from above four hundred pages of printed matter. The work is elaborate and painstaking to a fault; the author's patience in recording observations and measurements are worthy of all praise, and deserve to be rewarded by more important discoveries than he seems to have made, so far as we can judge from a cursory glance over the volume. A. G.

3. *Revisio Potentillarum Iconibus Illustrata;* auctore C. Lehmann. 4to, 1856.—More than thirty years have passed since Dr. Lehmann published his Monograph of Potentilla. From time to time ever since, he

* A valued correspondent suggests the propriety of adding a glossary of technical terms peculiar to the Cryptogamia, and a conspectus or catologue of the genera under each order or alliance. He also notes a few errors in the localities, &c., of certain American Fungi referred to. Thus, "*Trichamphora* (p. 335) is said to be from South Carolina; whereas it came from Pennsylvania. *Triphagmium deglubens* (p. 325) is given from Texas; but has as yet been found only in New Mexico. *Peridermium* is said (pp. 316, 317) to occur on *Ephedra* in South Carolina, instead of in Texas. *Trypethelium* (p. 387) is denied a residence in South America, yet we know that the author has Carolina specimens from thence in his herbarium, and he acknowledges as much on p. 394, and figures its fruit on p. 393. *Ravenelia* is reported (pp. 305, 316) to be found on *Desmodium*, but is thus far known only upon species of *Tephrosia*. Mr. Berkeley has figured two species of Fungi to which he applies the original herbarium names, forgetting that they have since been published under others. *Helminthosporium Hoffmanni* (p. 298) is *H. Ravenelii*, Curt., in this Journal and in Ravenel's Fungi Caroliniani. *Sartvellia foveolata* (p. 318) is *Dasyspora foveolata*, Berk. and Curt., in Journ. Acad. Nat. Sci., Philad.; the original name having been changed in consequence of Dr. Sartwell being already honored with a genus of higher dignity.—These are minor blemishes, easy to be corrected in another edition, and not detracting from the essential value and great interest of the work."

has given supplements, with descriptions and figures of new species, in his *Pugilli Plantarum*, besides elaborating the North American species in Hooker's *Flora Boreali-Americana*, so that the few large genera have been more attended to or have been longer under the constant revision of one critical eye. In 1851, a full conspectus of the species, newly arranged, and with a full synonymy, was published in the ninth Pugillus. And now, in a bulky supplement to the 23d volume of the *Nova Acta Academiæ Naturæ Curiosorum*, the indefatigable author, has brought out a new monograph of the genus, with 204 species (including the postscript), illustrated by 64 plates, containing figures of 78 species. So that, with these and the plates of the earlier monograph and its supplements, the iconography of the genus is almost complete. Five large tables display the whole geographical distribution of each species, as far as known, in a very complete manner, the area in which species of the genus occur being divided into about 90 sub-regions. Like all Dr. Lehmann's works, this monograph is most faithfully elaborated; and botanists are greatly indebted to him for the long and conscientious labor he has bestowed upon this difficult genus. A. G.

4. *Conspectus Systematicus Hydrillearum;* auctore R. Caspary. Berlin: 1857. pp. 15, 8vo. (From the Proceedings of the Roy. Acad. Sciences of Berlin, Jan. 1857.)—Dr. Caspary has been studying this little group (represented in this country by *Anacharis Canadensis*) with distinguished ability and success; but his little pamphlet shows that much yet remains to be done before the genera and the species can be regarded as well settled. He admits three genera, viz. *Hydrilla* and *Elodea* of Richard, and *Lagarosiphon* of Harvey; the former of a single Asiatic and European! species, the second having only American species, be the same more or less, and the third of one South African and one North African species. Planchon and Babington's mistake of the subhermaphrodite and dicœcious states of our North American species as generically distinct, which we pointed out at the time, is rightly comprehended by Dr. Caspary, who, however, has hesitated to reduce the several false species that were published. His four North American species are undoubtedly forms of one. Whether the whole tribe is not reducible to one genus is still an open question. But if *Hydrilla* has anatropous ovules, it should probably be kept distinct. The orthotropous ovules of Anacharis were long ago indicated by Dr. Torrey, and figured in the Botany of the State of New York, of which work Dr. Caspary evidently was ignorant. Generic distinctions between *Lagarosiphon* and *Elodea* or *Anacharis* are not patent. Under the circumstances we do not think it right in Dr. Caspary to attempt the restoration of the name *Elodea;* for, although Nuttall was wrong in supposing it the same as *Elodes* of Adanson, it is too near it in sound and structure, and the Hypericaceous genus has been generally adopted in that form, while the name *Anacharis*, adopted by Planchon and Babington, had also come into general use. Here is surely a case of *summum jus, summa injuria;* and it would be wiser to "let pretty well alone."

The different forms of the flowers of our *Anacharis Canadensis* still need investigation; and the writer of this notice asks for flowers and flowering branches of the plant, especially for male flowers, preserved in spirits. A. G.

5. *Mémoire sur le Vallisneria spiralis, L.;* par AD. CHATIN. Paris: 1855. pp. 31, 4to, with 5 plates.—The *Vallisneria*, famous in botanical literature, is here treated, 1st, as to organography and vegetation; 2d, as to the organogeny of the flower; 3d, its anatomy; 4th, its teratology; and 5th, its physiology. Upon the latter points the author has nothing of any consequence to say; nor do his investigations of the organography and organogeny of the plant offer any important points for notice. The so-called staminodia of the female flowers he shows to be petals, according to the prevalent view. That the ovules are orthotropous is a fact which he announced in the year 1854. The same fact was published in this country in 1848. Their dispersion over the walls of the ovary is apparently an original observation; but the note remarking that orthotropous ovules were not before known to be borne on funiculi was written in forgetfulness of Helianthemum and other Cistaceæ, in which slender funiculi have long been familiarly known. A. G.

6. *Freshwater Bivalves.*—The following is a list of papers recently published by I. Lea, of Philadelphia, in the Proceedings of the Academy of Natural Sciences of Philadelphia.

Descriptions of four new species of exotic Uniones.—Descriptions of thirteen new species of exotic Peristomata.—Descriptions of fifteen new species of exotic Melaniana.—Description of the byssus of the genus Unio.—Descriptions of eleven new species of exotic Uniones, from Georgia.—Remarks on Triquetra contorta.—Remarks on the visual organs of the Naiades.—Descriptions of thirteen new species of Uniones, from Georgia.—Descriptions of twelve new species of Uniones, from North Carolina.—Descriptions of six new species of Uniones, from Alabama.—Descriptions of eight new species of Naiades, from various parts of the United States.—Descriptions of three new species of Naiades.

7. *Agassiz.*—The first volume of Agassiz's great work is all printed, excepting a few pages.

## IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Cold weather.*—The record of the thermometer, at Dartmouth College, has been kept twenty-three years, and shows the past month to have been the coldest of that period. The Januarys of 1844, 1840 and 1837, were remarkable for their severity, but yield the palm to January, 1857.

The mean temperatures, at the hours of observation, viz. 7½ A. M., 1½ P. M., and 9½ P. M., together with the average, and the highest and lowest temperature of these respective months, are given below. Also the approximate average of all the means, for the Januarys of the period of twenty-three years.

| | 7½ A. M. | 1½ P. M. | 9½ P. M. | Average. | Highest. | Lowest. |
|---|---|---|---|---|---|---|
| January 1857, | 1°·3 | 15°·0 | 5°·2 | 7°·2 | 36° | −39° |
| " 1844, | 0 ·7 | 17 ·7 | 5 ·3 | 7 ·9 | 44 | −30 |
| " 1840, | 0 ·4 | 18 ·8 | 7 ·3 | 8 ·8 | 40 | −33 |
| " 1837, | 1 ·1 | 18 ·5 | 8 ·0 | 9 ·2 | 46 | −31 |
| Average for 23 years, | 11 ·2 | 25 ·3 | 16 ·1 | 17 ·5 | 46 ·5 | −21 |

The lowest temperatures observed during each of the winters of this period of twenty-three years, beginning with that of 1835, are as follows: −30, −24, −16, −16, −33, −24, −18, −31, −29, −32, −20, −29, −22, −34, −21, −33, −29, −23, −13, −29, −26, −18, −39. Average −25·6.

Some of the coldest days of the present winter with the temperature at the hours of observation are given below:

| | $7\frac{1}{2}h.$ | $1\frac{1}{2}h.$ | $9\frac{1}{2}h.$ |
|---|---|---|---|
| December 17, | −17° | − 7° | −15° |
| " 18, | −22 | − 1 | − 3 |
| January 16, | −22 | 7 | 8 |
| " 18, | −22 | − 4 | − 7 |
| " 23, | −26 | −16 | −28 |
| " 24, | −39 | − 2 | 1 |
| " 25, | −17 | 10 | − 7 |
| " 26, | −21 | 8 | 12 |

For the sake of comparison, some of the coldest days noted on the register are added.

| | $7\frac{1}{2}h.$ | $1\frac{1}{2}h.$ | $9\frac{1}{2}h.$ | Average. |
|---|---|---|---|---|
| Jan. 4, 1835, | −32° | − 7° | −29° | −22°·7 |
| Dec. 16, 1835, | −15 | −17 | −16 | −16 ·0 |
| " 17, 1835, | −17 | − 6 | −12 | −11 ·7 |
| Feb. 3, 1836, | −29 | − 4 | − 6 | −13 ·0 |
| Jan. 4, 1837, | −27 | − 5 | −12 | −14 ·7 |
| " 17, 1840, | −33 | − 2 | −13 | −16 ·0 |
| " 28, 1844, | −30 | − 2 | − 9 | −13 ·7 |
| Dec. 12, 1845, | −29 | − 2 | −18 | −16 ·3 |
| Jan. 11, 1848, | −34 | 1 | − 1 | −11 ·3 |
| Feb. 6, 1850, | −33 | − 4 | −10 | −15 ·7 |
| Jan. 30, 1851, | −29 | − 4 | −18 | −17 ·0 |
| " 29, 1854, | −29 | − 4 | −20 | −17 ·7 |
| Dec. 20, 1854, | −25 | − 6 | −17 | −16 ·0 |
| Feb. 6, 1855, | −22 | −16 | −20 | −19 ·3 |
| " 7, 1855, | −26 | − 1 | − 2 | − 9 ·7 |
| Jan. 5, 1856, | −18 | − 6 | − 3 | − 9 ·0 |
| " 23, 1857, | −26 | −16 | −28 | −23 ·3 |

From the above it will be seen that January, 1857, was the coldest month, the 23d the coldest day, and the morning of the 24th the coldest morning of the last twenty-three years. The first on the preceding list of cold days, Jan. 4, 1835, approximates very nearly to the temperature of the 23d Jan., 1857.

In this locality an extreme depression of the temperature is usually accompanied with a calm state of the atmosphere, and consequently the severity of the cold is not so keenly felt as a much less degree of cold in places exposed to the wind. A remarkable exception occurred on the 16th of December, 1835, when the temperature of −17° was accompanied through the day with a strong north wind, rendering the cold of that day more intensely severe and distressing than that of any other in the whole period.

Our extreme cold days often occur in clusters of from three to six or even ten days. There are nearly seventy such periods noted on our record. The most remarkable of these commenced on Jan. 25th, 1844, and continued seven days, during which the morning observations of the thermometer averaged −24°·7, and the evening −12°·1, and the noon only 1·7. Lowest −30°.

Another period of six days commenced Feb. 2d, 1836, during which the average of the morning observations was −20°·8, and the evening −7°·3. Lowest −29°.

Another period of ten days commenced Jan. 3d, 1835, during which the average of the morning observations was $-15°{\cdot}6$, and of the evening $-5°{\cdot}3$. Lowest $-32°$.

Another period of eight days commenced Feb. 13th, 1849; average of morning observations $-15°{\cdot}4$, and evening $-1°{\cdot}4$. Lowest $-21°$.

Another commenced Jan. 16, 1852, and continued seven days; the morning average was $-11°{\cdot}8$, evening $-4°{\cdot}4$. Lowest $-23°$.

The recent period of four days, from the noon of Jan. 22, 1857, gives a morning average of $-25°{\cdot}8$; evening $-12°{\cdot}7$; noon $-1°{\cdot}0$, and lowest $-39°$.

The mercury did not quite congeal in our thermometers on the morning of the 24th of January, but would doubtless have done so at the Hanover bridge, in the valley, 140 feet lower than our village, had not the owner of the instrument, on perceiving the rapid descent of the mercury on the evening of the 23d, taken it in, to prevent its freezing and bursting. He was not aware that mercury, unlike water, contracts, on congealing, instead of expanding. In low grounds surrounded by precipitous hills the temperature, when the air is still, is generally some degrees lower than in more elevated localities. Thus at the White River Junction (which is about 187 feet lower than our village), and at several other places in our vicinity, the mercury is reported to have frozen. It may be proper to remark, that the carefully conducted experiments of Dr. Kane, in his Arctic expedition, show that the specimens of distilled mercury which he subjected to trial, congealed at temperatures from $-38°{\cdot}5$ to $-41°{\cdot}5$, and after congealing, contracted so as to give an indication of $-44$. The observations of Sir Edward Belcher confirmed these results, the congealed mercury, in his experiments, contracting to $-46°$. Pouillet gives the point of fusion of mercury at $-39°{\cdot}2$. The results of spirit thermometers, at a very low temperature, should be received with caution. Dr. Kane found that six spirit thermometers which were selected as the most consistent of nearly thirty, and all of which at temperatures above $-40$ agreed within $1°{\cdot}8$, read as follows at noon, Feb. 5, 1854: $-71°$, $-63°$, $-54°$, $-50°$, $-50°$, thus differing 21 degrees. This probably owing to the different conditions of the alcohol with which they were filled, in respect to purity, and the quantity and quality of coloring matter employed. Y.

Dartmouth College, Jan. 31, 1857.

2. *Filtration through Sand.*—Experiments by Mr. Henry M. Witt, at the Chelsea waterworks, (England) have proved that by simple filtration of water through sand, soluble salts as well as suspended matters are separated. Out of 65·527 of solid residue dissolved and suspended, 24·237 were separated, including 7·559 of soluble salts, (1·820 of these chlorid of sodium). From water containing 55·60 of solid residue, 32·75 were thus separated 3·404 of which were dissolved salts. Hence mere percolation through sandy strata for long periods may separate dissolved saline ingredients from waters. Mr. Witt applies the facts to explain the occurrence of freshwater springs on coral islands, that ebb with the tide.—*Phil. Mag.* [4] xii, 23. But here Mr. Darwin's explanation seems most reasonable:—that the freshwaters are from the rains; and that being detained upon the coral rock, and at the same time being lighter than the

salt water of the ocean, the setting in of the tides pushes the fresh waters before them.

3. *Density of the Earth.*—The experiments of the Astronomers in the Harton Coal Pit, according to Rev. S. Haughton, (Phil. Mag. [4], xii, 50), give for the mean density of the earth, 5·480. The pit was 1260 feet deep, and the seconds pendulum gained $2\frac{1}{4}$ seconds per day at the bottom of the coal pit.

But the calculations of Mr. Airy, the Astronomer Royal (ib. p. 231) as given in the same Journal, vol. xii, p. 231, arrive at 6·566 as the mean density, which number at page 468 is changed to 6·809—6·623, the variation depending on the relative value of some of the observations.

Lieutenant Colonel James has deduced (Phil. Mag. [4], xii, 314) from the deflection of the Plumb-line at Arthur's Seat (Scotland), that the mean density of the earth is 5·14.

4. *Artesian Well of Mondorf.*—This well has reached a depth of 2247 Parisian feet, having passed through 54·11 meters of lias, 206·02 keuper, 142·17 muschelkalk, 311·45 variegated sandstone, 16·24 older slates and grauwacke. The temperature at bottom is 27·63° C., equivalent to an increase of 1° C., in depth for every 31·04 meters.—*Walferdin, in Compt. Rend.*, xxxvi, 250.

5. *Notice of a brilliant Meteor seen near Lake Winnibigoshish, Minnesota, April* 11, 1857; by Rev. B. F. Odell.—The sky at the time was partly covered with thin stratus clouds, and was moreover somewhat hazy. Being at the river, at about ten minutes before 9 P. M., the whole scene became suddenly almost as light as day, and on looking up I saw a meteor of the greatest splendor, in the constellation Hydra. Its course was nearly due west, and it did not occupy more than four seconds in sweeping across the southern heavens. It seemed to me to be greater than that of the full moon. It vanished a few degrees above the horizon, without any noise or evidence of explosion, leaving a bright streak of light, perhaps a degree in breadth, extending from a few degrees above the eastern horizon to within a degree of the western. In one or two minutes, this streak vanished, except a portion about 15° in length, which remained visible five or ten minutes, though gradually changing its form, and losing its brilliancy. Its appearance was that of a streak of vapor suspended in the atmosphere, gradually diffusing itself and distorted by the unequal currents of air to which its different parts were exposed. The whole moved very slowly to the north or northeast, but the western portion much the fastest, thus causing it to take a shape resembling the letter S.

6. *Prof. Bailey.*—The collections of microscopic objects made by Professor Bailey, and his library of works connected with that department of science, were bequeathed by him to the Boston Society of Natural History.

7. *American Association for the Advance of Science.*—The next meeting of the Association will open at Montreal on the 12th of August next.

8. *Key to the Geology of the Globe:* an essay designed to show that the present geographical, hydrographical, and geological structures, observed on the earth's crust, were the result of forces acting according to fixed, demonstrable laws, analogous to those governing the development of organic bodies; by Richard Owen, M.D., Prof. Geol. and Chem. in

the University of Nashville. 256 pp., 8vo. Illustrated by maps and diagrams. New York: 1857. A. S. Barnes & Co.—The author attempts to trace analogies between organic and world development. The work is the result of much thought, and contains valuable suggestions. There are undoubtedly real analogies of the highest meaning between the two systems of development; but they are to be found in the profound laws of progress, which are, in fact, simple philosophical principles, and not in details of structure. There are ideas running alike through the successive phases of both; but to attempt to find in the earth any analogy to the special organism of an animal is to mistake the whole bearing of the subject; and this is where the work of Professor Owen diverges from the true philosophy of nature.

9. *Coast Survey Report for the year* 1855. 420 pp., 4to. Washington: 1855.—This Report by Prof. A. D. Bache is a massy volume containing the results of a years' progress in the great work he has in charge. One-half the volume consists of maps of the surveys made on different parts of our eastern and western coasts, besides diagrams illustrating special researches by Prof. Bache and officers in the survey.

10. *Fossils of South Carolina;* by M. Tuomey and F. S. Holmes.—Nos. 9 and 10 of this fine work contain a continuation of the descriptions of South Carolina Pleiocene fossils, with five lithographic plates.

11. *The U. S. Naval Astronomical Expedition to the Southern Hemisphere, during the years* 1849—1852. Volume VI, Magnetical and Meteorological observations, under the direction of Lieut. J. M. Gilliss, LL.D., Superintendent. 430 pp., 4to. Washington: 1856.—The tables of which this volume consists, are a full exhibition of all the magnetic and meteorological observations made in Gilliss's Astronomical Expedition. The observations have been reduced and the means calculated, evidently with great labor. The special points which are noted are, absolute declinations at Santiago, Chili, the diurnal changes of declination, variations of horizontal force at different places in Chili, observations to determine the absolute horizontal force and calculations for different places, magnetic term-day observations; mean atmospheric pressure at the several observation hours of each month, quarterly and annual means; mean temperature in the same manner, for the hours, the months, and year, maxima and minima and daily range; and similar detail as to the mean temperature of evaporation, the winds, clouds and rain. This is the third volume of the Report thus far issued. The work is a great one, and we look for its completion with deep interest.

12. *Familiar Astronomy, or an Introduction to the Study of the Heavens.* Illustrated by celestial maps, and upwards of 200 finely executed engravings; to which is added a Treatise on the Globes, and a Comprehensive Astronomical Dictionary, for the use of schools and private students; by Hannah M. Bouvier. 499 pp., 8vo. Philadelphia: 1857. Childs & Peterson.—This new volume on astronomy is an excellent work, exceedingly well adapted for class instruction in schools or academies, and at the same time well calculated by its thoroughness and attractive character to disseminate astronomical knowledge beyond the walls of the academy. It is superior in its typography, remarkably beautiful in its numerous wood cuts, precise and pure in its English, full in its illustrations, and up to the times in its science. A considerable

number of comets and nebulæ are figured, and although but wood engravings, they are nearly equal to the best on steel. The work commences with the general principles of physical astronomy, which occupy Part I. Part II embraces Descriptive Astronomy; Part III, Sidereal Astronomy; Part IV, Practical Astronomy, treating of the principles and construction of telescopes and other instruments; Part V, contains a Treatise on the Globes; Part VI, the History of Astronomy. The plan of the work is on the system of questions and answers, which is convenient for teachers, and is so well carried out as to have scarcely any of the objections usually urged against the method.

13. *The Testimony of the Rocks, or Geology in its bearings on the Two Geologies, natural and revealed;* by HUGH MILLER. 500 pp., 12mo. —This work is too well known and fully appreciated to require remark in this place. We wish it may be universally read, as the last message of one who knew by experience the profound truths and harmonies of the two revelations—the testimony of the rocks and of the written word. The title page presents the theme of the work in a sentence from Job, "Thou shalt be in league with the stones of the field."

14. *A Manual of the Detection of Poisons, by Medico-chemical analysis;* by Dr. F. J. OTTO, Prof. Chem. in Caroline College, Brunswick; translated from the German, with notes and additions, by WM. ELDERHORST, M.D., Prof. Chem. Rensselaer Polytech. Inst., Troy, N. Y. New York: 1857. 178 pp., 12mo. H. Bailliere.—A valuable little work by an eminent German chemist, in which a large subject is brought judiciously into a small compass. Prof. Elderhorst has made some additions to the original treatise.

15. *Elements of Chemistry, including the Applications of the Science in the Arts;* by THOMAS GRAHAM, F.R.S.L. and E., late Professor of Chemistry in University College, London. 2d ed., revised and enlarged, edited by A. WATTS, B.A., F.C.S. Vol. II, Part II. New York: 1857. C. E. Bailliere.—This is a handsome reprint of the well known chemistry of Professor Graham.

16. *Chemical Problems and Reactions*, to accompany Stöckhardt's Elements of Chemistry; by J. P. COOKE, Jr. 130 pp., 12mo. Cambridge: 1857.—In the usual method of teaching chemistry, the knowledge gained consists usually of vague ideas and incoherent facts, or if clear and intelligent, it fails of that thoroughness which is needed to render it an instrument in the hands of the student. Professor Cooke of Harvard, has done a good service to the science in the publication of this book of Problems and Reactions. The student is led directly into the subject of equivalents and chemical physics. By definite problems, the learner is made to calculate the results of reactions, the yield of one product or another, and the proportions for saturation in various cases, the reduction of weights and measures, the weight of air and gases of specific amounts under different states of barometric pressure and temperature, the use of symbols, and modes of deducing formulas. The work was prepared for his own classes at Cambridge, but will be found useful wherever chemistry is taught.

OBITUARY.—A. DUFRENOY, the distinguished French mineralogist, and head of the School of Mines, died at Paris, in March last.

Lith. of J. Bien, 107 Fulton St. N.Y.

U. S. COAST SURVEY

A. D. BACHE Supdt.

# LINES OF EQUAL MAGNETIC DIP AND HORIZONTAL INTENSITY

FOR THE YEAR 1850

Scale 1/20,000,000

1856

Dip ———— Hor. Int .....

Lith. of J. Bien, 107 Fulton St. N.Y.

# U. S. COAST SURVEY

A. D. BACHE Supdt.

LINES OF

# EQUAL MAGNETIC DECLINATION

FOR THE YEAR 1850

Scale 1/20.000.000

1856

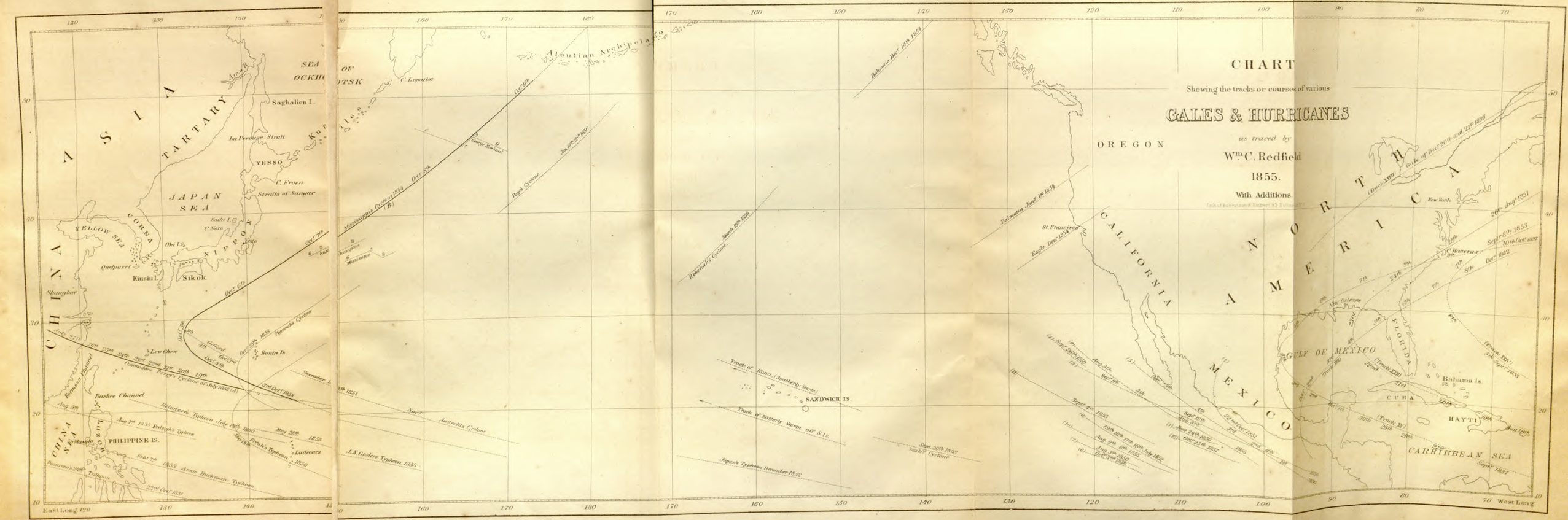


CHART
Showing the tracks or courses of various
GALES & HURRICANES
as traced by
Wm C. Redfield
1855.
With Additions
ASIA
TARTARY
CHINA SEA
JAPAN SEA
YELLOW SEA
COREA
NIPPON
YESSO
Saghalien I.
La Perouse Strait
C. Froen
Straits of Sangar
Saddo I.
C. Nata
Oki I.
Yedo
Quelpaert
Kinsui I.
Sikok
Shanghae
Lew Chew
Bashee Channel
PHILIPPINE IS.
Luzon
Ladrones
Bonin Is.
Aleutian Archipelago
C. Lopatka
SEA OF OKHOTSK
SANDWICH IS.
OREGON
CALIFORNIA
MEXICO
NORTH AMERICA
New York
New Orleans
GULF OF MEXICO
FLORIDA
Bahama Is.
CUBA
HAYTI
CARRIBEAN SEA
C. Hatteras
Eagle Dec. 1853
St. Francisco
Batavia Jan. 14. 1859
Dubuque Dec. 1838
Rebekah's Cyclone
March 30th 1836
Track of Kent. (Southerly Storm)
Track of Westerly Storm on S. Is.
Japan's Typhoon December 1832
Clarke's Cyclone
Sept. 20th 1843
Austerlitz Cyclone
Nov.
J.N. Cosders Typhoon 1855
Annie Huckman. Typhoon
Reindeer. Typhoon July 19th 1855
Eclipse Typhoon
Pearl's Typhoon
Typhoon
Fogel Cyclone
Jan. 30th 1839
Oct. 19th
Oct. 8th
Oct. 7th
Oct. 6th
Oct. 5th
Oct. 4th
Oct. 3rd
Oct. 2nd
Oct. 1st
Sept. 30th
Sept. 29th
Sept. 28th
Sept. 27th
Sept. 26th
Sept. 25th
Sept. 24th
Sept. 23rd
Sept. 22nd
Sept. 21st
Sept. 20th
Sept. 19th
Sept. 18th
Sept. 17th
Sept. 16th
Sept. 15th
Sept. 14th
Sept. 13th
Sept. 12th
Sept. 11th
Sept. 10th
Sept. 9th
Sept. 8th
Sept. 7th
Sept. 6th
Sept. 5th
Sept. 4th
Sept. 3rd
Sept. 2nd
Sept. 1st
Aug. 31st
Aug. 30th
Aug. 29th
Aug. 28th
Aug. 27th
Aug. 26th
Aug. 25th
Aug. 24th
Aug. 23rd
Aug. 22nd
Aug. 21st
Aug. 20th
Aug. 19th
Aug. 18th
Aug. 17th
Aug. 16th
Aug. 15th
Aug. 14th
Aug. 13th
Aug. 12th
Aug. 11th
Aug. 10th
Aug. 9th
Aug. 8th
Aug. 7th
Aug. 6th
Aug. 5th
Aug. 4th
Aug. 3rd
Aug. 2nd
Aug. 1st
July 31st
July 30th
July 29th
July 28th
July 27th
July 26th
July 25th
July 24th
July 23rd
July 22nd
July 21st
July 20th
July 19th
July 18th
July 17th
July 16th
July 15th
July 14th
July 13th
July 12th
July 11th
July 10th
July 9th
July 8th
July 7th
July 6th
July 5th
July 4th
July 3rd
July 2nd
July 1st
June 30th
June 29th
June 28th
June 27th
June 26th
June 25th
June 24th
June 23rd
June 22nd
June 21st
June 20th
June 19th
June 18th
June 17th
June 16th
June 15th
June 14th
June 13th
June 12th
June 11th
June 10th
June 9th
June 8th
June 7th
June 6th
June 5th
June 4th
June 3rd
June 2nd
June 1st
May 31st
May 30th
May 29th
May 28th
May 27th
May 26th
May 25th
May 24th
May 23rd
May 22nd
May 21st
May 20th
May 19th
May 18th
May 17th
May 16th
May 15th
May 14th
May 13th
May 12th
May 11th
May 10th
May 9th
May 8th
May 7th
May 6th
May 5th
May 4th
May 3rd
May 2nd
May 1st
Apr. 30th
Apr. 29th
Apr. 28th
Apr. 27th
Apr. 26th
Apr. 25th
Apr. 24th
Apr. 23rd
Apr. 22nd
Apr. 21st
Apr. 20th
Apr. 19th
Apr. 18th
Apr. 17th
Apr. 16th
Apr. 15th
Apr. 14th
Apr. 13th
Apr. 12th
Apr. 11th
Apr. 10th
Apr. 9th
Apr. 8th
Apr. 7th
Apr. 6th
Apr. 5th
Apr. 4th
Apr. 3rd
Apr. 2nd
Apr. 1st
Mar. 31st
Mar. 30th
Mar. 29th
Mar. 28th
Mar. 27th
Mar. 26th
Mar. 25th
Mar. 24th
Mar. 23rd
Mar. 22nd
Mar. 21st
Mar. 20th
Mar. 19th
Mar. 18th
Mar. 17th
Mar. 16th
Mar. 15th
Mar. 14th
Mar. 13th
Mar. 12th
Mar. 11th
Mar. 10th
Mar. 9th
Mar. 8th
Mar. 7th
Mar. 6th
Mar. 5th
Mar. 4th
Mar. 3rd
Mar. 2nd
Mar. 1st
Feb. 29th
Feb. 28th
Feb. 27th
Feb. 26th
Feb. 25th
Feb. 24th
Feb. 23rd
Feb. 22nd
Feb. 21st
Feb. 20th
Feb. 19th
Feb. 18th
Feb. 17th
Feb. 16th
Feb. 15th
Feb. 14th
Feb. 13th
Feb. 12th
Feb. 11th
Feb. 10th
Feb. 9th
Feb. 8th
Feb. 7th
Feb. 6th
Feb. 5th
Feb. 4th
Feb. 3rd
Feb. 2nd
Feb. 1st
Jan. 31st
Jan. 30th
Jan. 29th
Jan. 28th
Jan. 27th
Jan. 26th
Jan. 25th
Jan. 24th
Jan. 23rd
Jan. 22nd
Jan. 21st
Jan. 20th
Jan. 19th
Jan. 18th
Jan. 17th
Jan. 16th
Jan. 15th
Jan. 14th
Jan. 13th
Jan. 12th
Jan. 11th
Jan. 10th
Jan. 9th
Jan. 8th
Jan. 7th
Jan. 6th
Jan. 5th
Jan. 4th
Jan. 3rd
Jan. 2nd
Jan. 1st
Dec. 31st
Dec. 30th
Dec. 29th
Dec. 28th
Dec. 27th
Dec. 26th
Dec. 25th
Dec. 24th
Dec. 23rd
Dec. 22nd
Dec. 21st
Dec. 20th
Dec. 19th
Dec. 18th
Dec. 17th
Dec. 16th
Dec. 15th
Dec. 14th
Dec. 13th
Dec. 12th
Dec. 11th
Dec. 10th
Dec. 9th
Dec. 8th
Dec. 7th
Dec. 6th
Dec. 5th
Dec. 4th
Dec. 3rd
Dec. 2nd
Dec. 1st
Nov. 30th
Nov. 29th
Nov. 28th
Nov. 27th
Nov. 26th
Nov. 25th
Nov. 24th
Nov. 23rd
Nov. 22nd
Nov. 21st
Nov. 20th
Nov. 19th
Nov. 18th
Nov. 17th
Nov. 16th
Nov. 15th
Nov. 14th
Nov. 13th
Nov. 12th
Nov. 11th
Nov. 10th
Nov. 9th
Nov. 8th
Nov. 7th
Nov. 6th
Nov. 5th
Nov. 4th
Nov. 3rd
Nov. 2nd
Nov. 1st
Oct. 31st
Oct. 30th
Oct. 29th
Oct. 28th
Oct. 27th
Oct. 26th
Oct. 25th
Oct. 24th
Oct. 23rd
Oct. 22nd
Oct. 21st
Oct. 20th
Oct. 19th
Oct. 18th
Oct. 17th
Oct. 16th
Oct. 15th
Oct. 14th
Oct. 13th
Oct. 12th
Oct. 11th
Oct. 10th
Oct. 9

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

---

ART. XIII.—*Biographical Memoir of the late François André Michaux;* by ELIAS DURAND.*

FRANÇOIS ANDRÉ MICHAUX was born on the 16th of August, 1770, at Satory, a royal domain situated in the vicinity of Versailles, which, for several generations, had been intrusted by the Crown to the administration and management of his ancestors. He was the only son of André Michaux, who, with Catesby, Clayton, Bartram, Kalm and Walter, was one of the pioneers of botanical explorations in the North American regions. His mother Cecile Claye, was a daughter of a rich farmer of Beauce. She died, eleven months after her marriage, leaving behind her, a son, the subject of this notice.

Of the early life of François André Michaux, I have not been able to collect much information. It is probable that he was brought up on the farm of Satory in the practical school of his father, and of one of his uncles, upon whom devolved, after the departure of the former, the sole management of this extensive royal estate. It may be inferred also from his writings and instructive conversation, that his collegiate education had not been neglected.

His father, whose history is inseparably linked with that of his son, had devoted all his life to the progress of agriculture and the sciences; his main ambition had been to effect something

* From the Transactions of the American Philosophical Society, Vol. XI, p. xvii. Read Dec. 5th, 1856.

that might redound to the advantage of his native country, and, with this view, he had early turned his attention to agriculture, the advancement of which, he had soon perceived, could not be more securely attained, than by enriching its domain with such products of foreign climes as were unknown to his own country, and susceptible of acclimation. In order to accomplish his object, he determined to visit new regions, possessing climates similar to that of France, and to bring back thence such of their productions as might prove of advantage to his native land.

To effect that purpose, he prepared himself by a proper course of studies, and by devoting his particular attention to the science of Botany, under the great Bernard de Jussieu. He first visited England; he next made several explorations in the mountains of Auvergne, and in the Pyrenees, and afterwards in Spain. He next embarked for Persia, in the capacity of Secretary to the French Consul at Ispahan, but, in reality, for the sole purpose of exploring that country, then almost unknown to scientific men. From 1782 to 1785, he surveyed the whole of the Persian provinces, between the river Tigris and the Euphrates, and returned to France, with an extensive collection of specimens, and a large quantity of seeds of every kind.

During the absence of the elder Michaux, the French government had been agitating the important question of introducing into the forests of France, such exotic trees as would be calculated to increase the national resources, with respect to naval constructions. The information which had been received from the United States in this regard, had been exceedingly encouraging, and Michaux, who had just returned from Asia, was chosen for that particular errand, with instructions to procure, for the royal nurseries, all the young trees, shrubs and seeds he could possibly send. In consequence he made all proper dispositions, and embarked at Lorient on the 25th of August, 1785, taking with him his son, then only fifteen years of age, and a journeyman gardener of the name of Paul Saulnier, of whom I shall speak hereafter. They landed at New York on the first of October following.

At this remote period of time, I am altogether without record as to the movements of young Michaux, immediately after his landing on our shores. The only source where I expected naturally to obtain information, was the manuscript journal in which his father was in the habit of registering the daily incidents of his eventful life, and which had been deposited by his son in the library of the American Philosophical Society. Unfortunately, this journal has become incomplete, through the absence of three of its fasciculi, containing the years 1785. 1786 and 1790, which were lost in the shipwreck of the elder Michaux on the coast of Holland. In the fasciculus of 1787, young Michaux's

name appears for the first time on the date of May 6th, as accompanying his father in his exploration to the sources of the Keovee river. In the next spring, he is seen again with him, journeying into the interior of Florida. He is afterwards mentioned several times, as being retained at the Charleston Nursery, either on account of ill health, or intrusted with the management of the plantation, during the journeys of his indefatigable and ever-moving father.

In the further perusal of the manuscript, I learn, at the date of the 20th of September, 1789, that, on that day, his son walking along the road, was hit by a man shooting at partridges, and that a grain of shot had penetrated his left eye, below the pupil. From that date to December following, he occasionally speaks of the state of his son, of the treatment applied to his case, and, especially, of the great despondency of mind in which the patient had fallen, from the apprehension of losing his eye. But, here again we arrive at the third lost fasciculus, and I cannot ascertain the final result of the accident, nor at what time, precisely, young Michaux returned to France.

His return must have taken place in the first three months of 1790, for, in the manuscript of the following year, on the 17th of January, the elder Michaux acknowledges the receipt of a letter from his son, dated Paris, April, 1790, but nothing more is said about the wounded eye. To that accident, which is not generally known, may be attributed the partial deprivation of sight with which Michaux was afflicted.

Young Michaux therefore reached his country at the very outbreak of the French revolution, in which he is said to have warmly sympathized with the republican party. Such a course was not, perhaps, expected from one who had been brought up on a royal domain, and was, to a certain degree, indebted to royal munificence. But, on the other hand, how could the feelings of this generous and impressible young man be otherwise enlisted? His exalted patriotism, his ambition to serve his country, his frank and bold temper; his love of liberty, which he had imbibed in this free and happy land—all these together must have raised his spirits to a high pitch, in conjunction with the vexation he experienced when, on his return, he scarcely found a few remnants of the several hundred thousand young trees, which his father and himself had reared, in their American nurseries, and sent home for the particular benefit of his country. One half of these had been given away by the Queen to her imperial father of Austria; the rest had been squandered among the minions of the court, to embellish their grounds, or shamefully neglected in the royal nurseries of Rambouillet.

In the mean time, the elder Michaux was continuing his explorations in North America. He travelled in all directions,

over more than three thousand miles, during the eleven years which he spent on this side of the Atlantic. While thus actively engaged, the political storm, raging in his country, had brought on immense changes in his situation. France ruined by royal profligacy; invaded by famine; deluged with the blood of her best citizens; convulsed by civil war and fighting, single-handed, with the whole of Europe, could no longer afford to pay her naturalists abroad. Consequently, Michaux was forgotten, and ceased gradually to receive his salary. After having borrowed money on his own account; after having sacrificed a portion of his own, and of his son's fortunes, he found himself under the necessity of returning to his country. Unfortunately he was shipwrecked on the coast of Holland, and, after having lost the best part of his immense collections, he arrived in Paris on the 26th of December, 1796, after an absence of eleven years and four months.

On his arrival in his native land, the elder Michaux occupied his time in the cultivation of the vegetable treasures which he had forwarded from the United States, and in arranging his materials for the *history of the North American Oaks*, and for his *Flora Boreali-Americana*. In these various labors, he was assisted by his son, who, in the meantime, was studying medicine under the celebrated Corvisart, and attending the clinical lectures of Désault, chief surgeon of the Hotel Dieu, with the view of returning to the United States, and devoting himself to the practice of medicine; but such was not his destiny!

Neither the retired habits of a student, nor the easy and monotonous life of a Parisian abode suited temperaments like those of the two Michaux. Such men needed activity and change of scene, even with toils and perils. Both were animated with the same spirit of enterprise, with the same conviction that their efforts, employed in other directions, could afford more benefit to their country; hence, they were endeavoring, through the influence of their numerous friends, to infuse their views and projects into the minds of their fellow members of the Central Society of Agriculture, and of the ministers of Napoleon, then First Consul of the French Republic.

In this finally they both succeeded. The elder Michaux accepted a commission of naturalist in the scientific expedition led by Captain Baudin, and bound to the Australian seas, on condition, however, that he would be permitted to remain at the Isle of France, if he desired so to do. Disgusted with Baudin's haughty manners and want of courtesy to the scientific corps, André Michaux abandoned the expedition at Mauritius, where he remained six months, and then started for the island of Madagascar, which, he thought, would afford him better opportunities of advancing the science of botany, and making himself more useful to his country.

After sundry explorations along the coast, he established a botanical garden at Tametave, in which he planted all the trees and plants which might be objects of usefulness or curiosity. The climate, unfortunately, was exceedingly unhealthy, and trusting too much to his good constitution, and habits of exposure, he neglected the proper precautions, was taken sick with fever, and died at the end of December, 1803.

François André Michaux, on his own account had not remained inactive. Aroused by the example of his father, and now fully arrived at manhood, he could not look back to the unfinished work of his father in the United States, without becoming alive with the most ardent desire to achieve the object which they both had in view. Conversant with several States of the Union, confident in his own experience and abilities further to serve his country, he was, on his side, earnestly soliciting a commission to the United States.

This opportunity was at last afforded him through the celebrated De Chaptal, then Minister of the Interior, who feeling dissatisfied with the result of the nurseries of New Jersey and Charleston, since the departure of the elder Michaux, and thinking more benefit would accrue from the appointment of native correspondents in the principal seaports of the Union, consulted François A. Michaux in the matter, and appointed him to effect those objects. He gave him instructions, at the same time, to sell the properties, when he should have forwarded home all the trees and shrubs remaining in the two French nurseries above mentioned.

Michaux, highly gratified, set out immediately for Bordeaux, at which port he embarked for Charleston, with the same captain, and on the same vessel that had brought him home thence, some ten years previous. After a short and pleasant passage, he landed at his place of destination, on the 9th of October, 1801. He occupied himself almost immediately, and during the following winter, in sending to France the trees and shrubs of the nursery, and this part of his instructions being fulfilled, he embarked for New York on the same errand.

As soon as the season became favorable, he began his herborizations in New Jersey, and along the banks of North River. In these explorations, he discovered several new species of Oaks and Hickories, the acorns and nuts of which he sent to France in abundance. He had also the opportunity of determining with more accuracy, the botanical characters of the Black Oak (*Quercus tinctoria*,) one of the largest trees of the American forests, and, also, one of the most valuable for the good quality of its wood, as well as for its dyeing properties.

He next visited Philadelphia, where he had the pleasure of becoming acquainted with some of her most celebrated men,

among whom he mentions the Rev. Dr. Collin, Dr. Benj. S. Barton, Messrs. Vaughan, Peale, Wm. Bartram, &c. He visited with great satisfaction, the botanical garden of the last mentioned gentleman, and the magnificent green houses of Mr. Wm. Hamilton, which contained a rich collection of exotics, principally New Holland plants. His attention was more particularly attracted by the latter gentleman's romantic grounds, called Woodland, wholly planted with every American tree and shrub that could withstand the severity of a Philadelphia winter. Then, finding he had a few months to dispose of, he took advantage of this circumstance to visit the states of Kentucky and Tennessee, about which he had so frequently heard his father speak in the most enthusiastic terms.

Accordingly, he set out from Philadelphia, on the 27th of June, 1802; passed through Lancaster, Columbia, York, Carlisle and Shippensburgh; then crossing the Alleghany Mountains, he reached Pittsburgh in ten days, travelling alternately in stage, on horse-back and on foot. He left Pittsburgh on the 14th of July, on foot, for Wheeling, and there purchased a canoe to descend the Ohio river, in company with an American officer of the name of Craff. In three days, they reached Marietta, and, on the tenth day, they landed at Limestone, now Maysville. From that place, he travelled alone to Lexington, which he left on the 10th of August for Nashville.

Michaux remained in Nashville four weeks, which were employed, principally, in herborizations around the town and along the banks of the Cumberland river. On the fifth of September, he set out on his journey back to Charleston, by way of Fort Blunt, West Point and Knoxville, which latter place he reached on the 17th, after stopping several days at the Falls of Roaring River, to explore the beautiful country around. From Knoxville he travelled to Greenville, and thence to Jonesborough, the last town of Tennessee. On the 21st he began crossing the high ridge which divides the State of Tennessee from North Carolina, and after two days of the most toilsome journey through the mountains, he reached the farm of old Davenport, who had been formerly his father's guide in that rugged region.—There he remained a week, for the double purpose of resting and conversing with him about his dear father, who, shortly after, on the inhospitable coast of Madagascar, died a victim to the climate and to his zeal for the progress of science. On the second of October, Michaux reached Morgantown, two hundred and eighty miles from Charleston, and arrived in the latter city, on the 18th, by way of Lincolntown, Chester, Winsborough, and Columbus, after having travelled over eighteen hundred miles in three months and a half.

Such was François André Michaux's exploring journey to the Western states, of which he published a very detailed account, two years afterwards, in a work entitled "*Voyage à l'Ouest des Monts Allegheny, &c. &c.,*" During this journey, he did not merely devote his attention to botanical pursuits; but, with his usual habits of observation and extraordinary sagacity of mind, he diligently inquired into the state and modes of agriculture; the nature of the different soils; their particular vegetable productions, and the commercial relations existing between those remote regions and the Atlantic cities. He ever afterwards felt a considerable pleasure in relating the episodes of this long and toilsome journey through these regions, then but thinly settled, and yet the abode of the roving Indian tribes.

He spoke with enthusiasm, and in terms of unreserved gratitude, of attentions of which he was the object; his name was a passport which insured to him a most hearty welcome, and every assistance from those who had known his father, and had received from him seeds for planting or instructions in farming. To the new settlers he was always provided with letters of introduction, which procured him the same good reception. Every where he was hailed with manifestations of respect for the memory of his father, and with unanimous expressions of a desire to be useful to the son in any way within their power.

Michaux remained in Charleston until the first of March, 1803, when he embarked again for France, in the same vessel on board of which he had sailed from the port of Bordeaux, eighteen months before, and landed at that port on the 26th of the same month. On his arrival in Paris, he made every effort in hastening the publication of his father's "*Histoire des chênes d'Amérique,*" which had been printed in 1801, but the plates of which had not yet been completed. He attended also to the publication of the "*Flora Boreali-Americana,*" under the supervision of Claude Richard, an eminent botanist and a superior writer. Both these works were finally announced to the scientific world in the years 1803 and 1804, and were eagerly expected by those who took an interest in the vegetable productions of North America.

In the latter year, Michaux published his "*Journey to the West of the Alleghany Mountains,*" and the following year his memoir "*Sur la Naturalisation des Arbres Forestiers de l'Amérique du Nord.*" In this memoir, addressed to the Central Society of Agriculture of Paris, of which he was a prominent member, he endeavored to prove the great advantage which might accrue to France from the acclimation of better trees than those which her native forests actually possess, and of such, principally, as might well succeed in soils too poor for any of the French trees to thrive therein. In support of his opinion, he pointed out the swampy lands of France, as producing no wood of any value, whilst sim-

ilar lands in America are covered over with noble and valuable trees, such as the red Elm, Willow, Oak, white Cedar, white and black Cypress, &c. He, likewise, pointed at the sandy, and certain cretaceous soils of France, as giving growth to nothing but dwarfish and insignificant pines, while the equally arid lands of the southern states produce an abundance of the live Oak, a tree exceedingly valuable in naval architecture, and which might also well succeed in the sandy maritime soils of the southern departments of France.

Besides these advantages, Michaux proposed to increase the number of forest trees,—which, in France, attaining the height of thirty feet, is limited to thirty-six, eighteen of these forming the bulk of the forests, and seven only being employed in civil and naval constructions—whilst he alone had observed in the North American forests as many as one hundred and forty species of similar height and utility.

The means proposed by Michaux to attain these desiderata, were simply "to send a naturalist to the United States, with the mission to collect seeds and young trees, and to forward the same to the national nurseries of France." His propositions were forcibly supported in a report made to the Central Society of Agriculture by Messrs. De Perthuis, Correa de Serra and Cels, and he was, finally, intrusted with this mission, under the special patronage of the Duke De Gaëte, then minister of finance and for the account of the Administration of the Forests.

He, subsequently, embarked at Bourdeaux, on the 5th of February, 1806, in a vessel bound to Charleston. After being three days at sea, they were boarded by the British man of war Leander, Commander Witheby, who, suspecting the vessel to be laden for the account of French merchants, sent her to Halifax, there to be disposed of by the court of Admiralty, which would decide whether she was a legitimate prize, or should be liberated. Of all the passengers, Michaux was the only one ordered on board the Leander, where he remained during a cruise of forty-three days, after which they reached the Bermuda Islands. While in port, he was permitted freely to go ashore, and had thus the opportunity to make some interesting observations, the details of which he addressed to the Professors of the Paris Museum of Natural History, in a memoir entitled "*Notice sur les Iles Bermudes et particulièrement sur St. Georges.*"

Michaux was finally released, and permitted to sail for the United States, which he reached towards the end of May. Beginning his explorations at the district of Maine, where the winter is as rigorous as in Sweden, though ten degrees farther south, he travelled over all the Atlantic States as far as Georgia, where the heat during six months of the year, is as great as in the West Indies. Besides a journey of 1800 miles from northeast

to southwest, he made five explorations into the interior of the country:—The first, along the rivers Kennebeck and Sandy; the second, from Boston to Lake Champlain, crossing the States of New Hampshire and Vermont; the third, from New York to lakes Ontario and Erie; the fourth, from Philadelphia to the rivers Monongahela, Alleghany and Ohio; the fifth, from Charleston to the sources of the Savannah and Oconee rivers. In travelling along the sea-coast, he visited the principal dock-yards, with the view to examine the timber employed in ship-building; he also entered in all the work-shops where wood was worked into forms. As the knowledge of which he was in need was principally in the possession of artizans, he accordingly consulted the most skillful workmen, and by means of a series of questions, previously prepared, he collected a mass of valuable information.

In his different journeys to the interior, he paid particular attention to the trees that formed the bulk of the forests, with reference to the nature and uses of their woods, or as objects of commerce between the different states, or of exportation abroad. He ascertained the sources of the different barks employed in tanning, inquired into the quality and price of the various woods used for fuel, and formed a complete collection of polished specimens of the species employed in cabinet work or otherwise. In a word, the range of his observations was unlimited, and they could not fail to interest exceedingly the people of the United States, as well as Europeans, and to become one of the main points of the splendid work which he published, almost immediately after his return.

Michaux remained nearly three years in the United States, diligently employed in his arduous task. During his residence, he formed many valuable acquaintances. Besides the late Muhlenberg, Hamilton, Barton, Hosack, Alex. Wilson, Eddy, &c., he was on terms of friendship with others still living, among whom I may mention Dr. John Francis of New York and Major LeConte. Michaux was elected a Member of the American Philosophical Society on the 21st of April, 1809; and we have a proof of the value in which he held this honor, by the handsome provision made in favor of this institution, in his testament, bearing date of May 30th, 1852.

I should fail in my duty towards one, who was the companion and helpmate of the two Michaux, if I omitted here to mention his name. This is the humble Paul Saulnier, the same journeyman gardener who, in 1785, had accompanied them to this country, and was intrusted with the care of the New Jersey nursery. François Michaux never spoke of him but with feelings of respect and affection.

"Originally of France," says Dr. Francis in his eloquent discourse on the Natural Sciences, "his early life was absorbed in practical horticulture, as an experimenter in vegetable physiology, and as one of the subordinates of the Jardin des Plantes. Here, he had instilled into him the principles of the *ordines naturales*, by their author, de Jussieu. Shortly after, he was selected for his botanical attainments, to accompany the elder Michaux to this country. He proved serviceable as a collector. By royal means, Louis XVI, by whose patronage Michaux was authorized to procure American productions, a plot of ground in New Jersey was appropriated as a suitable garden for rearing and preserving plants and trees, mainly designed for the institutions of France.

In this sequestered place, Paul, with the exception of occasional excursions to New York and to parts adjacent, passed the remainder of his days. Here he was visited by the younger Michaux, Pursh, Douglas, Bradbury and other foreign naturalists who reached our shores. Poor Wilson, the Ornithologist, often found shelter within his humble dwelling from the lowering sky and tempestuous storms, and often I have heard Michaux enlarge on the refreshing enjoyment of Paul's hospitality. Paul was a sort of Sir Oracle with them; and his responses were heeded by all who sought practical knowledge in natural history. Paul, I believe, may be estimated the first, as to time, who without much pretension, inculcated among us the classification of Jussieu; and the arboriculturist may perhaps be now, for the first time, informed, that to him are we to assign the introduction into this country of the Lombardy poplar. Paul holds a place in the progress of botanical pursuits not unlike that enjoyed so long by the venerable Wm. Bartram, though I should be reluctant to assign to him a place as conspicuous as that of our philosophical traveller.

Let Michaux speak of the goodness of his heart and of his disinterested philanthrophy: "Paul was so exclusive in his attentions to his avocations, that hardly any other subject than trees and plants ever found entrance into his mind. To the day of his death, he considered his little circumscribed residence as still the property of his royal master; and ignorant of the vicissitudes of political revolution, reluctantly gave credence to the fact of the decapitation of his bountiful, but unfortunate King. Paul now lies in the Hackensack churchyard; his tomb-stone records not half his excellence."

On Michaux's return to Paris, he presented himself before the Central Society of Agriculture, to which he was mainly indebted for his mission to the United States, and there gave an account of his voyage, of the various tasks he had performed, and of the flattering results which had been already obtained:—From the

seeds which he had forwarded during his absence, more than two hundred and fifty thousand young trees had already sprung up, which were fairly promising to accomplish, in succeeding times, the objects contemplated by him, and confidently expected by his fellow members of the Society of Agriculture, who appointed a committee to report on the success of his voyage. Correa de Serra, chairman of that committee, in a most flattering report, highly complimented Michaux on the faithful execution of his trust, and for the importance of the services he had rendered to his country, he called forth a vote of thanks.

During the two years following his return, Michaux was actively employed in the publication of his great work: "*Histoire des Arbres Forestiers de l'Amérique du Nord,*" so anxiously expected by all who took an interest in the Flora of the United States, and in the observations of one so well versed in agricultural pursuits. The first volume appeared in 1810; the second, in 1812, and the third, in 1813.

This magnificent work, illustrated by 144 copper plates, designed by the two Redouté and by Bessa, and engraved by such eminent artists as Gabriel, Renard, Boquet, Bessin, and Dubreuil, was translated into English by Augustus L. Hillhouse, Esq., and published in Paris in four volumes by Charles D'Hautel (1817–1819) under the title of "*North American Sylva,*" with the addition of several plates and some new observations by the author. Mr. Wm. Maclure purchased the plates in Paris, and brought them to this country. To this circumstance is owing the publication of two American editions, which are likely, soon, to be followed by a third. The first, was issued at New Harmony, Indiana, 1842, and the second in this city, in 1852, with notes by J. J. Smith, Esq. Mr. Nuttall, soon after, published, on Michaux's plan, an additional *Sylva Americana,* describing and illustrating as many as one hundred and twenty trees, mostly unknown to his predecessor, indigenous to the far west regions, Oregon and California included.

Of this splendid work of Michaux, the author of an article on the botany of the United States, published in the thirteenth volume of the North American Review, remarks: "It is the plan of Michaux's history of our forest trees, to unite the advantages of a work strictly botanical and one relating to the useful arts; but, especially, to collect all the scattered details which books or experience could furnish him, with respect to the application of various kinds of woods to the purposes of life. Botanical descriptions can easily be made or found; but, in order to ascertain their useful properties, it was necessary to consult artisans in almost every branch of practical mechanics, to frequent dock-yards and work-shops in which wood was employed, and in short, to gather information from every attainable source. From these

inquiries Michaux had obtained a most extensive collection of curious and important facts, which rather belonging to the application of botany than to botany itself, are nevertheless essential to the complete knowledge of the plants of the United States; for, besides the commercial and practical uses of our trees, we have a very perfect account of the inflorescence, fructification, growth and botanical habit of them individually considered, as also many interesting facts with regard to them taken together as composing forests."

In a letter, dated October, 1852, addressed through Mr. Isaac Lea, to the President of the American Philosophical Society, Michaux expresses himself in the following words, with regard to his *Sylva Americana:* "The science of botany was the principal object of my father's explorations in North America, and the *Flora Boreali-Americana* was the result of those explorations. As for me, I took another view of the vegetable kingdom, whilst in your country—a view more limited and less scientific, it is true; but, perhaps, more generally profitable to the farmer and land-holder, as well as to that class of society, so numerous in the Northern States of the Union, who employ wood in so many different ways. I do not consider my *Sylva Americana* as complete as it might be: thus, for instance, I have omitted several species which grow in lower Lousiana, and in the two Floridas. In the second place I have described and figured some trees that are deficient in the flowers and in the fruits. Had circumstances permitted, I would have returned to the United States, and, in a new edition have corrected the errors, and filled up the omissions. I should thus have been able to present to the American nation, a work worthy of her great name, but now that I have arrived at a very advanced age, nearly 83 years, I can do nothing more, in this respect, than to express my regrets, and the hope that some native arboriculturist may complete my researches on the plan which I have adopted. The publication of such a work would be attended with much benefit to the country, and afford particular honor to him who would undertake it."

After the appearance of his great work, Michaux devoted all his attention to his favorite pursuits—the cultivation and propagation of trees, presenting a special object of public utility. Intrusted with the administration of a large estate belonging to the Central Society of Agriculture; experimenting largely in sylviculture on the extensive plantations of Mr. Delamarre, and owning himself a country place near Pontoise, he never ceased until his death, to be actively employed in experiments on arboriculture, either suggested by himself or others.

Michaux had retained in this country a few correspondents, who sent him occasionally new supplies of seeds, and through a letter furnished by one of these gentleman, I had the gratification to become acquainted with him in the autumn of 1824.

When living in Baltimore from 1816 to 1824, I formed an intimacy with a French gentleman of the name of Leroy, who had known Michaux in this country, and had been since in correspondence with him. This Mr. Leroy, who was himself an excellent arboriculturist, having been earnestly solicited by his friend to send him all the seeds and young trees which he could procure in the vicinity of Baltimore, applied to me, as a fellow botanist, to assist him in this undertaking. We, therefore, went to work together in earnest, during the autumn of 1819, rambling into the woods with a negro boy, climbing and beating Oaks, Maples, and Hickory trees; uprooting the shrubs and young trees that fell in our way, and collecting seeds of every sort. The result of our campaign filled up several large boxes which were forwarded to Michaux, in the early part of the winter.

When I visited Europe in 1824, Mr. Leroy favored me with a letter of introduction to his friend, recommending me as his co-laborer in the collections which had been forwarded to him from Baltimore, some years previous. This letter did not fail insuring to me a hearty welcome at the hands of Mr. Michaux. I saw him frequently, and breakfasted with him at his winter quarters in Paris, on the place St. Michael, which was then a market for garden vegetables and fruits. We seldom sat at the breakfast table, without having previously taken an inspection round through the stalls where fruits and vegetables were sold, and he was pleased to point out to me the rarest and most beautiful with a passing notice on their origin.

Mr. Michaux was extremely desirous to show me, in detail, his fine nurseries, especially those which contained his Maryland trees, to "*contemplate*" the result of the troubles and fatigues which they had cost me, but the weather was so unfavorable, during the whole season, that I could visit but one of them, which I found wholly planted with Maryland Oaks, and covering an extensive plot of ground. Though the young trees, then devoid of their foliage, had suffered much, the second year, from the depredations of a herd of swine that had trespassed upon these grounds, they still appeared vigorous and promising, and are, I suspect, the very same trees that are now (as I see by the Paris papers) adorning the Quai des Tuilleries, and some of the new Boulevards of the French metropolis, under the denomination of *American Oaks thirty-six years old.*

In acknowledgment of the service I had thus rendered him, Mr. Michaux presented me with a copy of the French edition of his magnificent work, beautifully bound in three volumes, and containing a double set of plates, the plain and colored.

Mr. Michaux's person was tall, strongly built; but not corpulent. His complexion was fair; he was slightly pock-marked,

and possessed prominent features. His light blue eyes had a peculiar expression which startled me at first. His countenance was stern and cold on first approach; but it smoothed off and brightened gradually, as he spoke and became more familiar; his utterance, in the beginning somewhat slow and cautious, became rapid and impressive, and his conversation gay and even humorous. All his manners were quite simple and unaffected, frank and lively—they were altogether those of an open-hearted country gentleman, in whose presence, young as I was at the time, I could feel neither embarrassment nor shyness.

I do not think that, after this interview with Michaux, his position and pursuits underwent much change. To the very last day of his life, he was fortunate enough to retain his health and his remarkable activity of body and mind. The main point of his arboricultural experiments, was to turn to advantage those lands, called heaths, which in France alone, do not cover less than two millions of acres, and were considered as utterly sterile. Through forty years of experiments, performed by him on the large demesnes belonging to the Central Society of Agriculture, and to Mr. Delamarre, he has ascertained that such lands could be improved and rendered productive by the cultivation of certain resinous trees, which succeed well in such soils. Of all the American and European pines with which he has experimented, Michaux gives the preference to the Russian Pine, *Pinus sylvestris*, which, in his letter to the President of the American Philosophical Society, above mentioned, he recommends warmly to the particular attention of the agriculturists of the Northern and Middle States of the Union.

With the view to render the scarcity of wood, under which this country is beginning to suffer, through the rapid and improvident destruction of the native forests, Michaux recommends also to the American people the cultivation of bushy or spreading trees, producing copses, or *Taillis*, to which he has applied a special mode of culture, more rational and more favorable to the development of vegetation, and, consequently, more profitable to the land-holders.

We are informed by the same letter, that Michaux was then preparing for publication a work in which he intended, succinctly, to develop his ideas on those interesting subjects, and to lay open the results of his observations and practical experience, for the particular benefit of the farmers and land-holders of the United States.

Michaux's last days were thus passed tranquilly, dividing his time between his favorite occupations of arboriculture, and the society of a few friends, among whom, the most intimate were President Seguier, Messrs. Macarel, D'André and Vilmorin. Louis Philippe himself, who had known him in this country,

never ceased to show him the greatest esteem and affection. He was always happy to see some transatlantic acquaintance. All the Americans, who have seen him in Paris, or at his country residence of Vauréal, can testify to the urbanity of his manners, and to the cordiality with which he received his visitors. In conversation with Americans, nothing afforded him more pleasure than the subject of this country. He listened with amazement to the wonderful accounts of its progress, of the rapid increase of its population, of its wealth and resources, of its success in war and in diplomacy. The names of new cities and innumerable towns, located on sites which, in his time, were still covered with the native forests; the mention of multifarious rail-ways, extending their arms in all directions and encircling the whole country in an immense net-work of iron; the speedy steam travelling by land and water, which would have rendered his long and painful journeys so short and so easy; in fine, the electro-magnetic telegraph, another offspring of American genius —all these wonderful achievements elicited from him the greatest amazement and the most emphatic exclamations: Mon Dieu, Mon Dieu, est il possible!

He felt proud to mention that he had been one of the first steam navigators, and boasted of an early acquaintance with Fulton, whom he met at Albany in 1807 under the following circumstances: He was then returning to New York city from his exploration to the lakes Ontario and Erie, and intended to take passage in a packet boat for New York; but seeing an advertisement of a steamboat to depart the same morning, he had the curiosity to examine her, and he determined to take passage on her. Strange to say, he and a Frenchman who accompanied him, were the only passengers on board; it was the first trial trip. Fulton was on board, and, as might be supposed, between two such men, speaking equally well the French language, an intimate friendship was formed, which continued through life. The ardor of this friendship on Michaux's part, was proved by his devotion to Fulton's memory.

Michaux, having found in Paris a model, in clay, of a bust of his friend by Houdon, bought it and caused it to be put in marble by the best artist he could find, at the cost of 1000 francs. He obtained permission afterwards from the Government to have it placed in the Marine Department of the Louvre, near that of Papin, who had done so much for steam.

Michaux's turn of mind was also literary. Besides his great work on *the North American trees*, *his journey to the west of the Alleghany Mountains* and the memoirs already mentioned, he published, in 1831, an essay *on the Planera crenata;* in 1852, a memoir on the *causes of Yellow Fever in the United States*, and another one *on the culture of the Vine.* He may have left also, at

his death, some unpublished papers, among which is probably the memoir alluded to in his last communication to the President of the American Philosophical Society. This communication dated, as I have said above, Vauréal near Pontoise, October 24th, 1852, was particularly intended to inform the President and his fellow-members that, desirous of giving the American nation a testimonial of his heartfelt gratitude for the hospitality and assistance which his father and himself had received in this country, during the course of their long and toilsome journeys, he had made testamentary provisions in favor of the Society, with the view to afford the means of promoting the progress of the science of Sylviculture in the United States.

This testament which Michaux had intrusted to the care of a gentleman of this city, Mr. Isaac Lea, whom he had consulted in the matter, was deposited four years ago in the archives of the Philosophical Society; but was not to be opened until after his death. This was done, consequently, on the 20th of October last, by the Recorder of Wills of the city of Philadelphia. By this document, he bequaths to the American Philosophical Society, the sum of fourteen thousand dollars, for special purposes connected with the particular object of his constant aspiration, "The progress of agriculture with reference to the propagation of useful forest trees." By the same instrument, he likewise endows the Society of Agriculture and Arts of Boston, with the sum of eight thousand dollars for similar purposes.

Michaux's demise was made known to the American public by Prof. Asa Gray in the columns of the American Journal of Science, vol. xxii, p. 137. It had been communicated to his lady, by a friend of Mr. Michaux, who thus relates the circumstances of his death: "I have to speak to you of the death of our good friend, Mr. Michaux. He was carried off with frightful suddenness by a stroke of apoplexy, on the 23d of October, 1855. He had been occupied the whole day, planting American trees, and he himself directing his journeymen. He withdrew from his work in good health, dined moderately, but with good appetite. He went to bed as usual, and fell asleep. At about one o'clock in the morning, his wife heard him move about and calling. She instantly rose from her bed, and ran to his apartment. He was still struggling on the floor, when she entered his room; but, on reaching him, she found that he had breathed his last. Physicians were called in immediately, but all in vain, life was totally extinct. He died at the age of eighty-five years."

Michaux left no issue. He had lived single to an advanced age, when quite suddenly, he became tired of celibacy, and changed abruptly his condition, by marrying a relative of his, who, for a long time, had been the manager of his house, his

attendant in sickness and companion in his solitude. They lived most happily together, and at his death, he left her a comfortable provision for the remainder of her life. Mr. Michaux was in easy circumstances, but by no means rich. To his title of Chevalier de la Légion d'Honneur, he added, those of Correspondent of the French Institute, of Member of the American Philosophical Society, of the Central Society of Agriculture of Paris, of the Society of Agriculture and Arts of Boston, &c., &c.

---

ART. XIV.—*Investigation on the Rock Guano from the Islands of the Caribbean Sea;* by WM. J. TAYLOR.*

THOUGH much has been written and published on the Columbian guano of the Caribbean Sea, (which is also termed phosphatic guano, native super-phosphate of lime, &c.,) I have considered the subject not entirely exhausted, and for some time past have been paying especial attention to its composition, besides endeavoring to gather all possible information regarding its mode of occurrence. To Dr. D. Luther, president of the Philadelphia Guano Company, I am particularly indebted for his kindness in furnishing me with material for the investigation from the various groups of islands, and for information regarding its occurrence. To Dr. F. A. Genth I am also indebted for allowing me to make the investigation in his laboratory.

The guano rock is found on islands northeast and north of the coast of Venezuela in the Caribbean Sea, and belonging to that republic; the islands form groups or keys composed of one hundred or more small islands, inhabited principally, and indeed almost solely, by water fowl, who resort there in immense numbers for laying their eggs. Mr. Cassin informs me that the birds are those commonly known as gulls, pelicans, and cormorants; these have been the instruments by which the immense deposits of guano have been formed. But what the process has been is a problem not yet fully solved.

The Columbian guano is a hard rock, consisting of two distinct portions; the outer exterior crust, consisting of a white, and frequently reniform coating, which, in places where it is not decomposed, has a polished surface not unlike enamel; it is composed of concentric layers, each of which is about two or more lines in thickness. The entire outer crust forms but a very small proportion of the whole rock; a carefully selected portion of this has been analyzed, which had not undergone any apparent decomposition, and upon which the enamelled surface was well preserved. In some portions the reniform surface is dis-

* From the Proceedings of the Academy of Natural Sciences of Philadelphia, March, 1857.

tinctly marked, and it resembles to a certain extent in its appearance the menilite of Menil Montant near Paris; the concentric layers composing it are well marked, and when they are fractured or cut across, an appearance is presented not unlike some varieties of agate.

The following is the result of an analysis:—

(I.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2·0266 grammes | ignited | lost | 0·1640 | grammes | gave | 13·03 | p. c. |
| " | " | Ag | 0·0274 | " | chlorine | 0·44 | " |
| " | " | CaO, $SO_3$ | 0·0419 | " | sulphuric acid | 1·93 | " |
| " | " | CaO, $SO_3$ | 1·9965 | " | lime | 40·64 | " |
| " | " | $2MgO, PO_5$ | 0·1654 | " | magnesia | 2·93 | " |
| " | " | $2MgO, PO_5$ | 1·1753 | " | phosphoric acid | 37·15 | " |
| " | " | residue | 0·0111 | " | residue | 0·55 | " |
| " | " | Na Cl | 0·1231 | " | soda | 3·23 | " |

| | | | | | |
|---|---|---|---|---|---|
| Loss by ignition, | 13·03 | per cent. | Oxygen ratio, | | |
| Chlorine, | 0·44 | " | " | | |
| Sulphuric acid, | 1·93 | " | " | " | 1·15 |
| Phosphoric acid, | 37·15 | " | " | " | 20·82 |
| Lime, | 40·64 | " | " | " | 11·55 |
| Magnesia, | 2·93 | " | " | " | 1·17 |
| Soda, | 3·23 | " | " | " | 0·82 |

From the oxygen ratio of this it appears that the phosphoric acid and lime exist in the proportion of $3CaO, PO_5$. The crucible after ignition showed indications that chlorid of iron had been volatilized.

Below this exterior crust the rock has a varied appearance; it is of a dark brown color, in places quite black, and varying in others to a lighter shade, in which portion are frequent cavities filled with minute crystals of gypsum, readily recognizable with a pocket lens. The darkest portion is the most solid, with a slightly vitreous lustre, and of a much greater density and hardness than any other portion of the guano; it has a sub-conchoidal fracture, sometimes splitting into thin fragments which are translucent; through some portions of it I have frequently observed thin irregular bands, $\frac{1}{32}$d to $\frac{1}{16}$th of an inch in width, which have the appearance of carbon.

This portion was selected for analysis with particular care, with the view to ascertain its exact composition; it was with difficulty reduced to the finest powder and treated with distilled water (in the cold) in a beaker glass, being frequently stirred for several days in order that the water should be in frequent contact with the particles; it was then collected on a weighed filter and washed with cold water until the filtrate showed no trace of sulphuric acid; the excess of filtrate was evaporated to dryness, and a thorough analysis made of it, the result of which is the following:—

(II.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3·9922 grammes | | 0·3836 | grams. | $BaO, SO_3$ | gave | sulphuric acid | 3·30 |
| " | " | 0·1761 | " | $CaO, CO_2$ | " | lime | 2·48 |
| " | " | 0·0099 | " | Ag | " | chlorine | 0·08 |
| " | " | 0·0531 | " | $2MgO, PO_5$ | " | phosphoric acid | 0 85 |
| " | " | 0·0089 | " | Na Cl | " | soda | 0·88 |

| | | | | | |
|---|---|---|---|---|---|
| Per-centage | sulphuric acid, | 3·30 | Oxygen ratio, | 1·97 | |
| " | " phosphoric acid, | 0·85 | " | " | 0·54 |
| " | " lime, | 2·48 | " | " | 0·70 |
| " | " soda, | 0·88 | " | " | 0·22 |
| " | " chlorine, | 0·08 | " | " | |

There was in this analysis a loss of lime or magnesia, and also of the insoluble residue.

A selection was made from other specimens which resembled very nearly that above described; it was treated in the same manner as (II), but the results show a marked difference, there being a smaller per-centage of phosphate of lime dissolved from (II) than from (III), and a proportional amount of chlorid of sodium. To this fact I shall again refer.

The following is the result of the analysis:

(III.)

The residue before weighing was carefully dried at 100° C.

| | | | | | |
|---|---|---|---|---|---|
| 2·7271 grammes | left, residue of 2·3177 gram. | | | | 84·98 |
| " | " 0·0095 grams. | Ag | gave | chlorine, | 0·11 |
| " | " 0·3603 " | $BaO, SO_3$ | " | sulphuric acid, | 4·91 |
| " | " 0·2536 " | $CaO, SO_3$ | " | lime, | 3·84 |
| " | " 0·0083 " | $2MgO, PO_5$ | " | magnesia, | 0·11 |
| " | " 0·0600 " | $2MgO, PO_5$ | " | phosphoric acid, | 1·58 |
| " | " 0·0201 " | Na Cl | " | soda, | 0·40 |

| | | | | |
|---|---|---|---|---|
| Chlorine, | 0·11 per cent. | Oxygen ratio, | | |
| Sulphuric acid, | 4·91 " " | " | " | 2·94 |
| Phosphoric acid, | 1·58 " " | " | " | 0·88 |
| Lime, | 3·84 " " | " | " | 1·09 |
| Magnesia, | 0·11 " " | " | " | 0·04 |
| Soda, | 0·40 " " | " | " | 0·10 |

From another portion of the rock the black portions were selected for analysis; the quantity of sulphate of lime is very inconstant. The results of the analysis were as follows:

(IV.)

| | | | | | | |
|---|---|---|---|---|---|---|
| 0·9170 grams. | ·0536 gram. | $BaO, SO_3$ | gave | sulphuric acid, | 2·01 | p. c. |
| " " | 0·0510 " | $CaO, CO_2$ | " | lime, | 3·13 | " |
| " " | 0·1532 " | $Fe_2O_3$ | " | sesquioxyd of iron, | 16·71 | " |
| " " | 0·1123 " | $Al_2O_3$ | " | alumina, | 12·25 | " |
| 2·0741 " | lost by heating, | 0·3254 | | | 15·69 | " |
| " " | insoluble residue, | 0·1314 | | | 6·13 | " |

Owing to an accident to the platinum crucible just before weighing, the phosphoric acid was not determined.

| | | | | | | |
|---|---|---|---|---|---|---|
| Sulphuric acid, | 2·01 | per | cent. | Oxygen | ratio, | 1·20 |
| Lime, | 3·13 | " | " | " | " | 0·89 |
| Sesquioxyd of iron, | 16·71 | " | " | " | " | 5·00 |
| Alumina, | 12·25 | " | " | " | " | 5·70 |

The specimens from which the material for the above analyses were selected, I received from Messrs. Richards and Miller, agents for the Philadelphia Guano Company; there is doubt as to their exact locality; in appearance they correspond exactly with that from Monk's Island, but the results of the analyses are very different from those obtained from the specimens from this island which I received from Dr. Luther.

That alumina is present as a phosphate, in the guano from Monk's Island, I have proved, by treating 3·4023 grammes of an average sample of the cargo of Schr. Trident from Monk's Island, with pure caustic potash in a silver dish, which was found to contain 1·32 per cent of alumina.

Specimens were given me from Monk's Island by Dr. Luther, the characteristic appearance of which has already been described.

1·5915 grammes were treated in a silver dish with potash, but not a trace of alumina could be detected; the residue dissolved in hydrochloric acid was found to contain lime, 39·08 per cent.

The guano rock from Monk's Island when finely powdered and treated with distilled water, gave an acid reaction with litmus paper.

(V.)

1·7076 grammes (organic matter and water not determined).

| | | | | | | |
|---|---|---|---|---|---|---|
| " | " | 0·1993 gram. | $BaO, SO_3$ | gave sulphuric acid, | 4·00 | p. c. |
| " | " | 0·0780 " | $2MgO, PO_5$ | " magnesia, | 1·64 | " |
| " | " | 1·1999 " | $CaO, CO_2$ | " lime, | 39·34 | " |
| " | " | 1·1461 " | $2MgO, PO_5$ | " phosphoric acid, | 42·98 | " |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sulphuric acid, | 4·00 | per | cent. | Oxygen | ratio, | 2·39 |
| Magnesia, | 1·64 | " | " | " | " | 0·65 |
| Lime, | 39·34 | " | " | " | " | 11·10 |
| Phosphoric acid, | 42·98 | " | " | " | " | 24·09 |

For the oxygen of the sulphuric acid, 2·39, there are required 0·88 of the oxygen of the lime; and if to the remainder be added the oxygen of the magnesia, we have 10·95, which is to the oxygen of the phosphoric acid very nearly as 1 : 2.

(VI.)

2·8678 grammes treated with distilled water gave:

| | | | | | | |
|---|---|---|---|---|---|---|
| " | " | 2·7076 grams. | residue, | | 94·41 | p. c. |
| " | " | 0·1287 " | $BaO, SO_3$ | gave sulphuric acid, | 1·49 | " |
| " | " | 0·0655 " | $CaO, CO_2$ | " lime, | 1·27 | " |
| " | " | 0·0363 " | $2MgO, PO_5$ | " phosphoric acid, | 0·81 | " |

2·8426 grammes treated with distilled water gave:

| | | | | | | |
|---|---|---|---|---|---|---|
| " | " | 0·0076 grams. | Ag | gave | chlorine, | 0·09 p. c. |
| " | " | 0·0347 " | 2MgO, $PO_5$ | " | phosphoric acid, | 0·78 " |
| " | " | 0·1099 " | BaO, $SO_3$ | " | sulphuric acid, | 1·33 " |

| | | | |
|---|---|---|---|
| Lime, | 1·27 per cent. | Oxygen ratio, | 0·36 |
| Phosphoric acid, | 0·81 " " | " " | 0·45 |
| Sulphuric acid, | 1·49 " " | " " | 0·89 |

Guano rock has been brought from another group of islands called Centinella, consisting of peaks, which sometimes attain a height of 800 feet. The rock is described as consisting of two layers, the upper of which is a dark-brown compact rock, varying slightly from the lower layer. This so-called lower layer has certainly a surface exposed, as the specimen which I have examined, has been much weathered; the outer portion is partially reniform, and in places it shows a slight enamel, though not near as distinctly as the specimens from Monk's and El Roque islands. It has evidently been formed in layers, which when broken across show a slightly banded appearance not unlike that already described as characteristic of portions of the rock from Monk's Island; the color varies from a buff to an ochreous brown; it is hard, brittle, and much more readily pulverized than the Monk's Island guano rock. An opinion may seem premature, but I am inclined to the belief that this has once been in the same condition as the guano rock from Monk's Island, which has undergone changes from causes not yet fully studied; this seems probable from the fact that small quantities of phosphate of alumina have been found in the Monk's Island rock.

The whitest portion of the rock was selected for an analysis, which gave the following results:

(VII.)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1·5165 grams. | ignited gave | ·3469 grams. | | | | 22·87 p. c. |
| " | " | 0·2000 grams. | insoluble matter, | | silica, | 13·18 " |
| " | " | 0·0474 " | BaO, $SO_3$ | gave | sulphuric acid, | 1·07 " |
| " | " | 0·6921 " | 2MgO, $PO_5$ | " | phosphoric acid, | 29·23 " |
| " | " | 0·0720 " | CaO, $CO_2$ | " | lime, | 2·66 " |
| 1·3048 " | | 0·2120 " | $Al_2O_3$ | " | alumina, | 16·24 " |
| " | " | 0·1628 " | $Fe_2O_3$ | " | sesquiox. of iron, | 12·41 " |
| " | " | 0·6438 " | 2MgO, $PO_5$ | " | phosphoric acid, | 31·60 " |
| " | " | 0·0660 " | CaO, $CO_2$ | " | lime, | 2·83 " |
| " | " | 0·0057 " | $2Al_2O_3, 3PO_5$? | " | phosph.of alumina, | 0·43 " |

| | | | | |
|---|---|---|---|---|
| Water? | 22·87 per cent. | Oxygen ratio, | 21·54 |
| Silica, | 13·18 " " | " " | 6·84 |
| Sulphuric acid, | 1·07 " " | " " | 0·65 |
| Phosphoric acid, | 31·60 " " | " " | 20·24 |
| Lime, | 2·66 " " | " " | 0·75 |
| Alumina, | 16·24 " " | " " | 7·59 |
| Sesquioxyd of iron, | 12·41 " " | " " | 3·61 |

The 0·65 of oxygen of the sulphuric acid requires 0·22 of the oxygen of the lime; the remaining lime is most likely combined with carbonic acid, as nearly every specimen on treating with dilute acid gave a slight effervescence (the guano rock from the vertical cliff contained nearly one per cent), or possibly a remnant of the once phosphate of lime still exists. The alumina and phosphoric acid exist most likely in the form of wavellite, which has the formula $3Al_2O_3$, $2PO_5 + 12HO$. It is difficult in a rock which is in progress of decomposition to obtain other than approximate formulæ.

This island of Centinella is now inhabited by immense numbers of water-fowl, many of which roost on the cliffs; some of these roosts have been long occupied, and judging from the signs on the rocks beneath, have been much resorted to. Mr. Richards of Philadelphia, who visited the islands a short time since, broke off a portion of the concretion which covers the cliffs beneath a bird roost of this description; the organic properties had been mostly removed by causes which had converted the inorganic constituents into a guano rock, which in composition is not unlike that from Monk's Island and El Roque. Mr. Richards mentioned that when first obtained it had quite a strong odor, which has now almost disappeared; it is very hard and was difficult to powder.

The analysis of the concretion is as follows:

(VIII.)

| | | | | | | |
|---|---|---|---|---|---|---|
| 2·0904 grams. | on ignition lost | 0·2361 gram. | | | 11·29 | p. c. |
| 2·2904 " | 0·0248 grams. | $Al_2O_3$ | gave | alumina, | 1·08 | " |
| ·8470 " | 0·066 " | $BaO, SO_3$ | " | sulphuric acid, | 2·67 | " |
| " " | 0·4707 " | $CaO, CO_2$ | " | lime, | 31·18 | " |
| " " | 0·0406 " | $2MgO, PO_5$ | " | magnesia, | 1·74 | " |
| " " | 0·0143 " | $Fe_2O_3$ & $Al_2O_3$ | " | iron and alumina, | 1·69 | " |
| " " | 0·0506 " | insoluble, | " | silica, | 5·97 | " |
| 1·8570 " | 1·0153 " | $CaO, CO_2$ | " | lime, | 30·68 | " |
| " " | 0·0926 " | $2MgO, PO_5$ | " | magnesia, | 1·79 | " |
| " " | 0·0346 " | $Fe_2O_3$ $Al_2O_3$ | " | alumina and iron, | 1·86 | " |
| " " | 1·2520 " | $2MgO, PO_5$ | " | phosphoric acid, | 41·89 | " |
| 1·2142 " | contained 0·0089 grams. | $CO_2$ | " | carbonic acid, | 0·73 | " |

| | | | | | |
|---|---|---|---|---|---|
| Alumina and iron, | 1·86 | per cent. | | Oxygen ratio, | 0·86 |
| Sulphuric acid, | 2·67 | " | " | " " | 1·59 |
| Carbonic acid, | 0·73 | " | " | " " | 0·54 |
| Lime, | 31·18 | " | " | " " | 8·86 |
| Magnesia, | 1·74 | " | " | " " | 0·69 |
| Phosphoric acid, | 41·89 | " | " | " " | 23·25 |

1·59 oxygen of sulphuric acid require 0·53 of oxygen of the lime; and 0·53 of oxygen of the carbonic acid require 0·27 oxygen of the lime; but if there is added to this remainder the oxygen

of the magnesia, there remains 8·75 oxygen of lime, which is to the oxygen of phosphoric acid 23·25, about in the ratio of 1 : 2, particularly as the oxygen of the alumina requires oxygen of the phosphoric acid, to form a salt with a formula most probably corresponding to that of wavellite as before mentioned.

Mr. Richards brought with him also a specimen of the recent alluvial guano or bird excrement, as it may be justly termed; he obtained it from a little nook in the rocks, where it was protected from the intense dry heat of the sun and from the action of water. Mixed through it were several birds feathers. As may readily be imagined, it had some odor, though not excessively strong.

7·4921 grams. were ignited in a platinum crucible, and gave a very strong and disagreeable odor like burning hair; it was moistened with carbonate of ammonia and again gently heated, and gave a loss of 4·0032 grams. = 53·83 per cent.

(IX.)

2·1975 grams. of the ash showed a trace of alumina.

| | | | | | | |
|---|---|---|---|---|---|---|
| " | " | 0·2746 grams. | $BaO, SO_3$ | gave sulphuric acid, | | 4·29 |
| 2·236 | " | 1·5150 " | $CaO, CO_2$ | " lime, | | 38·02 |
| " | " | 0·0913 " | sand | " | | 4·83 |
| 4·0704 | " | ignited gave a loss 1·9171 gram. | | | | 47·10 |
| 1·9997 | " | ash | | | | |
| " | " | 1·3858 grams. | $CaO, CO_2$ | gave lime, | | 38·89 |
| " | " | 0·2206 " | $BaO, SO_3$ | " sulphuric acid, | | 3·79 |
| " | " | 0·2100 " | $2MgO, PO_5$ | " magnesia, | | 3·77 |
| " | " | 1·3178 " | $2MgO, PO_5$ | " phosphoric acid, | | 42·21 |
| " | " | 0·0225 " | sand | " | | 3·25 |
| " | " | 0·0164 " | Ag | " chlorine, | | 0·26 |
| 3·9652 | " | loss by ignition 1·9282 gram. | | | | 48·62 |
| ·9857 | " | 0·6892 grams. | $CaO. Co_2$ | gave lime, | | 39·12 |
| ·9794 | " | 0·0085 " | $CO_2$ | " carbonic acid, | | 0·86 |
| " | " | 0·1250 " | $BaO, SO_3$ | " sulphuric, | | 4·28 |

| | | | | |
|---|---|---|---|---|
| Lime, | 38·89 per cent. | " | " | 23·65 |
| Phosphoric acid, | 42·21 " | " | " | 2·57 |
| Sulphuric acid, | 4·29 " | " | " | 1·50 |
| Magnesia, | 3·77 " | " | " | |

Oxygen ratio, 11·05

2·57 oxygen in sulphuric acid require 0·85 oxygen in lime; there remains 10·19 oxygen of lime, which, if added to the oxygen of the magnesia makes 11·69, which stands with the oxygen of the phosphoric acid 23·65, near the ratio $2CaO, PO_5$.

A guano rock has recently been brought from a group of islands called El Roque, in the Caribbean Sea. In composition it resembles very closely that brought from Monk's Island; the specimens that I have analyzed, contain however, a much larger quantity of sulphuric acid than has been found in the latter rock.

The appearance of the body of the two rocks is also much alike, but in the specimens which I have seen from El Roque the exterior crust is very different; it is rarely more than a slight coating; in some places it has a slight appearance of the enamel, when examined with a pocket lens; the surface is very irregular, often containing cavities which are lined with the same white coating. It was impossible to obtain sufficient of this for analysis: the analysis of the black portion of the rock was as follows:

(X.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1·8636 grms. | loss by ign. | 0·1904 grms. | water & organic matter | | | 10·22 | p. c. |
| 1·4609 " | 0·3274 grms. | $BaO, SO_3$ | gave | sulphuric acid, | | 7·70 | " |
| " " | 1·0066 " | $CaO, CO_2$ | " | lime, | | 38·67 | " |
| " " | 0·1118 " | $2MgO, PO_5$ | " | magnesia, | | 2·75 | " |
| " " | 0·0116 " | insoluble | | | | 0·78 | " |
| " " | 0·0058 " | $Fe_2O_3$ & $Al_2O_3$ | " | iron and alumina, | | 0·40 | " |
| 1·1680 " | 0·7936 " | $CaO, CO_2$ | " | lime, | | 38·12 | " |
| " " | 0·0879 " | $2MgO, PO_5$ | " | magnesia, | | 2·70 | " |
| " " | 0·7383 " | $2MgO, PO_5$ | " | phosphoric acid, | | 40·49 | " |

| | | | | |
|---|---|---|---|---|
| Organic matter and water, | 10·22 | per cent. | | |
| Sulphuric acid, | 7·70 | " " | Oxygen ratio, | 4·61 |
| Lime, | 38·67 | " " | " " | 10·09 |
| Magnesia, | 2·75 | " " | " " | 1·09 |
| Phosphoric acid, | 40·49 | " " | " " | 25·93 |
| Alumina and sesquioxyd of iron, | 0·40 | | | |
| Insoluble, | 0·78 | | | |

4·61 oxygen in sulphuric acid require 1·54 oxygen in lime; there remains therefore 8·55 oxygen in lime which stands with the oxygen of phosphoric acid 25·93, in the ratio 1 : 3, showing that the phosphate in this specimen consists principally of $3CaO, PO_5$.

A specimen containing no organic matter was examined from Testigoe Island, but the rock was very much disintegrated; it was very porous, and evidently had been acted upon by some causes which were gradually removing all its components except the silica. In appearance it was largely a sandstone, as the analysis showed. The most compact portion of the specimen was selected, which was readily pulverized; the results of the analysis differ from all the other specimens. The following are the results:

(XI.)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1·2910 grams. | insoluble silica | 0·6722 grams. | | | 52·07 | p. c. |
| " " | 0·0085 | $CaO, CO_2$ | gave | lime, | 0·37 | " |
| " " | 0·0206 | $2MgO$ | " | magnesia, | 0·57 | " |
| 0·8806 " | 0·1073 | loss by ignition | " | water, | 12·17 | " |
| 0·8806 " | insoluble | 0·4600 grams. | " | silica, | 52·27 | " |
| | | | | sulphuric acid, | *trace.* | |

0·8806 grams. 0·1158 $Al_2O_3$ gave alumina, 13·03 p. c.
" " $2Fe_2O_3$, $3PO_5$ } 0·0318 " phosphate of iron, 3·61 "
" " $2MgO, PO_5$ 0·2394 " phosphoric acid, 17·41 "

| | | | | | | |
|---|---|---|---|---|---|---|
| Silica, | 52·07 | per cent. | | | | |
| Lime, | 0·37 | " | " | | | |
| Magnesia, | 0·57 | " | " | | | |
| Water, | 12·17 | " | " | Oxygen ratio, | | 10·81 |
| Sulphuric acid, | *trace* | | | | | |
| Alumina, | 13·03 | " | " | " | " | 6·12 |
| Phosphate of iron, | 3·61 | " | " | | | |
| Phosphoric acid, | 17·41 | " | " | " | " | 9·81 |

The alumina and phosphoric acid seem in this to be in the form of wavellite.

The guano rock from the various groups of islands has very varying composition, as has been seen from the foregoing investigations. It is found in layers, and the surface sometimes covered with an alluvial deposit; these layers are in places highly inclined, showing that since their deposition their original position has been altered. This same phenomenon is described as occurring at the Chincha islands in the Peruvian guano where it is found in layers two or three yards in thickness.

Prof. C. U. Shepard has, with his characteristic energy, extended his mineralogical species to various portions of this rock. He designates the so-called species generally as Pyroguanite minerals, and describes them as entirely destitute of ammonia;* but examinations made of an average sample of a cargo from Monk's Island show one-half per cent of nitrogen. Every specimen which I have examined, has on ignition given very marked evidence of burning organic matter. How this can be retained in a rock that has been subjected to the agency of heated trap is as difficult to understand, as that minerals existing with, and forming a part of, its mass, as Prof. Shepard describes, contain water in their composition. Moreover, how can a rock subjected to the agency of heated trap have as its principal basis a salt with the formula $2CaO, HO, PO_5$, which is the formula ascribed to it by Drs. Piggot and Beckell, of Baltimore, and which seems to be the proper composition of some portions, as shown by the analysis of Monk's Island rock (V),—though in the analysis of the specimen from El Roque (X) there is obtained the formula $3CaO, PO_5$.

As I have already mentioned, this guano rock from *Los Monges* has been called a native super-phosphate of lime, but no satisfactory proofs are given as to its meriting such a name; phosphoric acid being found in solution after the guano is treated

* Am. J. Sci. [2], xxii, 96.

with water is no proof that it exists in a free state. Phosphate of lime, when recently precipitated, is soluble to a slight extent in pure water (R. Phillips, Ann. Phil. 22, 188). Berzelius long since discovered phosphates of lime and alumina in the water and deposits of hot springs at Carlsbad.* That phosphates are insoluble and must be rendered free before becoming efficacious as fertilizers is an erroneous though a very prevalent opinion. According to Bischof† phosphate of lime must be regarded as present in all water running into the sea; it has already been detected in the waters of the Dee and of the Don, and it will most likely be found in the waters of all rivers. Phosphate of lime and magnesia have also been found in the waters of an artesian well at Wildegg, in the Canton Argan (Switzerland). Phosphate of lime has been shown to be present in sea water by Clemm‡ and by Forchhammer.§ According to Berzelius it is the *di*-phosphate which is found in the mineral waters,‖ which is readily soluble in water saturated with carbonic acid. The basic phosphate of lime is also readily soluble in water containing carbonic acid; Bischof gives a very interesting table of the degrees of solubility of the various basic phosphates of lime in water saturated with carbonic acid gas.¶

It is not only in carbonic acid waters that phosphate of lime is soluble; basic phosphate of lime dissolves in 3·150 parts of water, containing one-twelfth by weight of chlorid of sodium. The presence of chlorid of ammonium increases the solubility still more.¶

It is probable, therefore, that the solubility of the phosphate of lime guano rock from Los Monges is owing to the presence of the chlorid of sodium existing in it. By reference to the analyses (II and III), it will be seen that the phosphate of lime dissolved is in proportion to the chlorid of sodium in the specimens. This will, however, require more detailed examination.

Though the rock from Centinella, containing so large a percentage of phosphoric acid combined with iron and alumina, may seem at first worthless as a fertilizer, no positive opinion should be formed or expressed without a very careful investigation of the subject, which I believe has never yet been made. It is true that phosphate of alumina is one of the most sparingly soluble substances known; still it is soluble in water saturated with carbonic acid, according to Bischof in about 6,828,000 parts, while in the water of the Carlsbad springs about double this quantity is held in solution, viz. $\frac{1}{3\,1\,2\,5\,0\,0\,0}$.**

* Gilbert's Annalen, lxxiv, 136.
† Chem. and Phys. Geology, vol. 2, p. 27 (Engl. edit.).
‡ Journ. für prakt. Chemie, xxxiv, 185. § Berzelius, Jahresbericht, xxvi, 393.
‖ Gmelin, vol. iii, p. 195. ¶ Chem. and Phys. Geology, vol. ii, p. 28.
** Chem. and Phys. Geol., vol. ii, p. 34.

Though the phosphate of lime is applied to soils, and, as such, taken up by plants, there is no proof that it remains in that form until the plants have need of it; it enters into new combinations, some of which may be quite as insoluble as this Centinella rock. The phosphate of lime dissolved by the carbonated waters always found more or less in soils,* is decomposed by alkaline carbonates; the lime would therefore be converted into a carbonate, and a phosphate of the alkali would be formed.† Boussingault and Levy, (Journ. des Debats, Dec. 5, 1852,) found that the air in the interstices of arable soils contained as much as 22 to 23 times as much carbonic acid as the atmosphere, and when the soil has been recently moistened, 245 times as much. Phosphate of lime lying in such a soil would be dissolved in a comparatively short space of time.

Carbonate of iron is present more or less in every soil, and consequently, if in a soil the carbonate of iron and phosphate of lime exist, both held in solution by a carbonate of the alkalies, a mutual decomposition may take place,‡ consequently we may have vivianite formed in the soil: instances are frequent of vivianite in fossils of the greensand of New Jersey,§ but geological ages are not required to produce these changes. M. Jerome Nicklès has recognized its presence in human bones (Am. Jour. of Sci., vol. xxi, p. 402); he found in a cemetery at Eumont, a village in the department of LaMeurthe, the earth of which was very ferruginous, two arm bones of a female, a cubitus and a radius, having a deep bluish green color. On breaking, the alteration was found to be complete, and a qualitative chemical examination proved it to be phosphate of iron. It is to be regretted that a quantitative analysis was not made, to have determined whether all the bone phosphate had been decomposed and the transformation into phosphate of iron complete. M. Nicklès, on examining the medullary cavity with a lens, found among the sinuosities left by the hardened marrow brilliant

* Researches have been made by Lassaigne, Journ. Chim. Med., [3], iv, 354; and Ann. de Chim. et de Phys., [3], xxv, 346, show that phosphate of lime is conveyed into the plant organism by water saturated with carbonic acid. Dumas (Comptes Rendus, xxiii, 1018) holds the same opinion.

† Bischof, Chem. and Phys. Geology, vol. i, p. 13, No. 19. Phosphate of lime dissolved in carbonated water forms carbonate of lime, which is precipitated, and alkaline phosphate which remains in solution.

‡ Phosphate of lime dissolved in carbonated waters and proto-carbonate of iron form a proto-phosphate of iron, which is precipitated, and bi-carbonate of lime which remains in solution. (Bischof, vol. i, p. 13, No. 20)

§ In the greensand of New Jersey, the decomposition is not owing probably to the carbonate of iron, but to the sulphate resulting from oxydation of the iron pyrites. (Bischof, vol. i, p. 14, No. 21.) Phosphate of iron and proto-sulphate of iron form sulphate of lime and proto-phosphate of iron. Similar changes probably result in this guano rock, as in many specimens we find crystals of gypsum recognizable with a pocket-lens.

points which were distinctly crystals of vivianite. The bones were in a perfect state of preservation, and afforded, when treated with hydrochloric acid, a skeleton of gelatine, proving that gelatine does not resist the absorption of the ferruginous compound.

Various theories have been formed and published as to the origin of the rock guano; these are most likely premature, as the accounts as to its occurrence are founded on reports of those not accustomed to noting geological phenomena.

The islands of the Caribbean Sea are very varied. Some are quite low and covered with sand composed of fragments of shells, madrepore and corals, which can readily be distinguished with a pocket lens. These sands are resorted to by myriads of waterfowls for laying their eggs. One of the captains who visited there mentions that it is necessary to make one's way through them with a stick. Other islands attain heights of 800 feet; it seems improbable that such heights could be created by accretions of guano and sand, when the islands were subject to a continued action of the waves of the ocean; and from the inclined position of the guano layers it might be inferred that an uplift had taken place since the layers were formed. But on this point more direct evidence is needed.

It is most probable that the guano rock from some of the islands has been changed in its composition by reactions of the salts contained in sea water; but before such reactions can be fully explained, accurate analyses must be made of this sea water.

It is a remarkable fact, that the composition of the ash from the recent guano from the heights of the Centinella rock composed of phosphates of alumina and iron, should have a composition so very near that of the guano rock from the Los Monges and El Roque islands. The frequent occurrence of alumina and iron is to be remarked in the guano rocks.

*Note.*—I have just been informed by Dr. Luther, that from analyses lately made in Baltimore of a cargo of rock guano that has lately arrived from the island of Testigoes, there has been found from forty to forty-five per cent of phosphoric acid.

ART. XV.—*On the Interaction of Natural Forces;** by H. HELMHOLTZ, Professor of Physiology in the University of Königsberg.†

A NEW conquest of very general interest has been recently made by natural philosophy. In the following pages I will endeavor to give a notion of the nature of this conquest. It has reference to a new and universal natural law, which rules the action of natural forces in their mutual relations towards each other, and is as influential on our theoretic views of natural processes as it is important in their technical applications.

Among the practical arts which owe their progress to the development of the natural sciences, from the conclusion of the middle ages downwards, practical mechanics, aided by the mathematical science which bears the same name, was one of the most prominent. The character of the art was, at the time referred to, naturally very different from its present one. Surprised and stimulated by its own success, it thought no problem beyond its power, and immediately attacked some of the most difficult and complicated. Thus it was attempted to build automaton figures which should perform the functions of men and animals. The wonder of the last century was Vaucanson's duck, which fed and digested its food; the flute player of the same artist, which moved all its fingers correctly; the writing boy of the older, and the pianoforte player of the younger Droz; which latter, when performing, followed its hands with its eyes, and at the conclusion of the piece bowed courteously to the audience. That men like those mentioned, whose talent might bear comparison with the most inventive heads of the present age, should spend so much time in the construction of these figures which we at present regard as the merest trifles, would be incomprehensible, if they had not hoped in solemn earnest to solve a great problem. The writing boy of the elder Droz was publicly exhibited in Germany some years ago. Its wheelwork is so complicated that no ordinary head would be sufficient to decipher its manner of action. When, however, we are informed that

* A popular scientific discourse, delivered the 7th of February, 1854. Cited from Phil. Mag., Fourth Serics, volume 11, page 489, where it is accompanied by the following note by the translator, John Tyndall, Ph.D., F.R.S.—"The following article is a translation of a popular lecture, but it will, I doubt not, be studied with interest by many of the readers of this Journal. I once had thoughts of presenting the lecture in a condensed form, omitting allusions, which though proper and necessary in a spoken discourse, might not appear so in a strictly scientific article. On reflection, however, I think it better to let the accomplished author state, in his own fashion, the important question which he has contributed so much to expand and elucidate."

† Now of the University of Bonn.

this boy and its constructor, being suspected of the black art, lay for a time in the Spanish Inquisition, and with difficulty obtained their freedom, we may infer that in those days even such a toy appeared great enough to excite doubts as to its natural origin. And though these artists may not have hoped to breathe into the creature of their ingenuity a soul gifted with moral completeness, still there were many who would be willing to dispense with the moral qualities of their servants, if at the same time their immoral qualities could also be got rid of; and accept, instead of the mutability of flesh and bones, services which should combine the regularity of a machine with the durability of brass and steel. The object, therefore, which the inventive genius of the past century placed before it with the fullest earnestness, and not as a piece of amusement merely, was boldly chosen, and was followed up with an expenditure of sagacity which has contributed not a little to enrich the mechanical experience which a later time knew how to take advantage of. We no longer seek to build machines which shall fulfil the thousand services required of *one* man, but desire, on the contrary, that a machine shall perform *one* service, yet shall occupy in doing it the place of a thousand men.

From these efforts to imitate living creatures, another idea, also by a misunderstanding, seems to have developed itself, which, as it were, formed the new philosopher's stone of the seventeenth and eighteenth centuries. It was now the endeavor to construct a perpetual motion. Under this term was understood a machine, which, without being wound up, without consuming in the working of it falling water, wind, or any other natural force, should still continue in motion, the motive power being perpetually supplied by the machine itself. Beasts and human beings seemed to correspond to the idea of such an apparatus, for they moved themselves energetically and incessantly as long as they lived, and were never wound up; nobody set them in motion. A connexion between the taking-in of nourishment and the development of force did not make itself apparent. The nourishment seemed only necessary to grease, as it were, the wheelwork of the animal machine, to replace what was used up, and to renew the old. The development of force out of itself seemed to be the essential peculiarity, the real quintessence of organic life. If, therefore, men were to be constructed, a perpetual motion must first be found.

Another hope also seemed to take up incidentally the second place, which in our wiser age would certainly have claimed the first rank in the thoughts of men. The perpetual motion was to produce work inexhaustibly without corresponding consumption, that is to say, out of nothing. Work, however, is money. Here, therefore, the great practical problem which the cunning

heads of all centuries have followed in the most diverse ways, namely, to fabricate money out of nothing, invited solution. The similarity with the philosopher's stone sought by the ancient chemists was complete. That also was thought to contain the quintessence of organic life, and to be capable of producing gold.

The spur which drove men to inquiry was sharp, and the talent of some of the seekers must not be estimated as small. The nature of the problem was quite calculated to entice poring brains, to lead them round a circle for years, deceiving ever with new expectations which vanished upon nearer approach, and finally reducing these dupes of hope to open insanity. The phantom could not be grasped. It would be impossible to give a history of these efforts, as the clearer heads, among whom the elder Droz must be ranked, convinced themselves of the futility of their experiments, and were naturally not inclined to speak much about them. Bewildered intellects, however, proclaimed often enough that they had discovered the grand secret; and as the incorrectness of their proceedings was always speedily manifest, the matter fell into bad repute, and the opinion strengthened itself more and more, that the problem was not capable of solution; one difficulty after another was brought under the dominion of mathematical mechanics, and finally a point was reached where it could be proved, that at least by the use of pure mechanical forces no perpetual motion could be generated.

We have here arrived at the idea of the driving force or power of a machine, and shall have much to do with it in future.

I must therefore give an explanation of it. The idea of work is evidently transferred to machines by comparing their arrangements with those of men and animals, to replace which they were applied. We still reckon the work of steam-engines according to horse power. The value of manual labor is determined partly by the force which is expended in it (a strong laborer is valued more highly than a weak one), partly, however, by the skill which is brought into action. A machine, on the contrary, which executes work skilfully, can always be multiplied to any extent; hence its skill has not the high value of human skill in domains where the latter cannot be supplied by machines. Thus the idea of the quantity of work in the case of machines has been limited to the consideration of the expenditure of force; this was the more important, as indeed most machines are constructed for the express purpose of exceeding, by the magnitude of their effects, the powers of men and animals. Hence, in a mechanical sense, the idea of work is become identical with that of the expenditure of force, and in this way I will apply it in the following pages.

How, then, can we measure this expenditure, and compare it in the case of different machines?

I must here conduct you a portion of the way—as short a portion as possible—over the uninviting field of mathematico-mechanical ideas, in order to bring you to a point of view from which a more rewarding prospect will open. And though the example which I shall here choose, namely, that of a water-mill with iron hammer, appears to be tolerably romantic, still, alas, I must leave the dark forest valley, the spark-emitting anvil, and the black Cyclops wholly out of sight, and beg a moment's attention to the less poetic side of the question, namely, the machinery. This is driven by a water-wheel, which in its turn is set in motion by the falling water. The axle of the water-wheel has at certain places small projections, thumbs, which, during the rotation, lift the heavy hammer and permit it to fall again. The falling hammer belabors the mass of metal, which is introduced beneath it. The work therefore done by the machine consists, in this case, in the lifting of the hammer, to do which the gravity of the latter must be overcome. The expenditure of force will in the first place, other circumstances being equal, be proportional to the weight of the hammer; it will, for example, be double when the weight of the hammer is doubled. But the action of the hammer depends not upon its weight alone, but also upon the height from which it falls. If it falls through two feet, it will produce a greater effect than if it falls through only one foot. It is, however, clear that if the machine, with a certain expenditure of force, lifts the hammer a foot in height, the same amount of force must be expended to raise it a second foot in height. The work is therefore not only doubled when the weight of the hammer is increased twofold, but also when the space through which it falls is doubled. From this it is easy to see that the work must be measured by the product of the weight into the space through which it ascends. And in this way, indeed, do we measure in mechanics. The unit of work is a foot-pound, that is, a pound weight raised to the height of one foot.

While the work in this case consists in the raising of the heavy hammer-head, the driving force which sets the latter in motion is generated by falling water. It is not necessary that the water should fall vertically, it can also flow in a moderately inclined bed; but it must always, where it has water-mills to set in motion, move from a higher to a lower position. Experiment and theory coincide in teaching, that when a hammer of a hundred weight is to be raised one foot, to accomplish this at least a hundred weight of water must fall through the space of one foot; or what is equivalent to this, two hundred weight must fall half a foot, or four hundred weight a quarter of a foot, &c. In short, if we multiply the weight of the falling water by

the height through which it falls, and regard, as before, the product as the measure of the work, then the work performed by the machine in raising the hammer, can, in the most favorable case, be only equal to the number of foot-pounds of water which have fallen in the same time. In practice, indeed, this ratio is by no means attained: a great portion of the work of the falling water escapes unused, inasmuch as part of the force is willingly sacrificed for the sake of obtaining greater speed.

I will further remark, that this relation remains unchanged whether the hammer is driven immediately by the axle of the wheel, or whether—by the intervention of wheelwork, endless screws, pulleys, ropes—the motion is transferred to the hammer. We may, indeed, by such arrangements succeed in raising a hammer of ten hundred weight, when by the first simple arrangement the elevation of a hammer one hundred weight might alone be possible; but either this heavier hammer is raised to only one-tenth of the height, or tenfold the time is required to raise it to the same height; so that, however we may alter, by the interposition of machinery, the intensity of the acting force, still in a certain time, during which the mill-stream furnishes us with a definite quantity of water, a certain definite quantity of work, and no more, can be performed.

Our machinery, therefore, has in the first place done nothing more than make use of the gravity of the falling water in order to overpower the gravity of the hammer, and to raise the latter. When it has lifted the hammer to the necessary height, it again liberates it, and the hammer falls upon the metal mass which is pushed beneath it. But why does the falling hammer here exercise a greater force than when it is permitted simply to press with its own weight on the mass of metal? Why is its power greater as the height from which it falls is increased? We find, in fact, that the work performed by the hammer is determined by its velocity. In other cases, also, the velocity of moving masses is a means of producing great effects. I only remind you of the destructive effects of musket-bullets, which in a state of rest are the most harmless things in the world. I remind you of the windmill, which derives its force from the moving air. It may appear surprising that motion, which we are accustomed to regard as a non-essential and transitory endowment of bodies, can produce such great effects. But the fact is, that motion appears to us under ordinary circumstances transitory, because the movement of all terrestrial bodies is resisted perpetually by other forces, friction, resistance of the air, &c., so that the motion is incessantly weakened and finally neutralized. A body, however, which is opposed by no resisting force, when once set in motion, moves onward eternally with undiminished velocity. Thus we know that the planetary bodies have moved without

change through space for thousands of years. Only by resisting forces can motion be diminished or destroyed. A moving body, such as the hammer or the musket-ball, when it strikes against another, presses the latter together, or penetrates it, until the sum of the resisting forces which the body struck presents to its pressure, or to the separation of its particles, is sufficiently great to destroy the motion of the hammer or of the bullet. The motion of a mass regarded as taking the place of working force is called the living force (*vis viva*) of the mass. The word "living" has of course here no reference whatever to living beings, but is intended to represent solely the force of the motion as distinguished from the state of unchanged rest—from the gravity of a motionless body, for example, which produces an incessant pressure against the surface which supports it, but does not produce any motion.

In the case before us, therefore, we had first power in the form of a falling mass of water, then in the form of a lifted hammer, and thirdly in the form of the living force of the falling hammer. We should transform the third form into the second, if we, for example, permitted the hammer to fall upon a highly elastic steel beam strong enough to resist the shock. The hammer would rebound, and in the most favorable case would reach a height equal to that from which it fell, but would never rise higher. In this way its mass would ascend; and at the moment when its highest point has been attained it would represent the same number of raised foot-pounds as before it fell, never a greater number; that is to say, living force can generate the same amount of work as that expended in its production. It is therefore equivalent to this quantity of work.

Our clocks are driven by means of sinking weights, and our watches by means of the tension of springs. A weight which lies on the ground, an elastic spring which is without tension, can produce no effects: to obtain such we must first raise the weight or impart tension to the spring, which is accomplished when we wind up our clocks and watches. The man who winds the clock or watch communicates to the weight or to the spring a certain amount of power, and exactly so much as is thus communicated is gradually given out again during the following twenty-four hours, the original force being thus slowly consumed to overcome the friction of the wheels and the resistance which the pendulum encounters from the air. The wheelwork of the clock therefore exhibits no working force which was not previously communicated to it, but simply distributes the force given to it uniformly over a longer time.

Into the chamber of an air-gun we squeeze, by means of a condensing air-pump, a great quantity of air. When we afterwards open the cock of a gun and admit the compressed air into

the barrel, the ball is driven out of the latter with a force similar to that exerted by ignited powder. Now we may determine the work consumed in the pumping-in of the air, and the living force which, upon firing, is communicated to the ball, but we shall never find the latter greater than the former. The compressed air has generated no working force, but simply gives to the bullet that which has been previously communicated to it. And while we have pumped for perhaps a quarter of an hour to charge the gun, the force is expended in a few seconds when the bullet is discharged; but because the action is compressed into so short a time, a much greater velocity is imparted to the ball than would be possible to communicate to it by the unaided effort of the arm in throwing it.

From these examples you observe, and the mathematical theory has corroborated this for all purely mechanical, that is to say, for moving forces, that all our machinery and apparatus generate no force, but simply yield up the power communicated to them by natural forces,—falling water, moving wind, or by the muscles of men and animals. After this law had been established by the great mathematicians of the last century, a perpetual motion, which should only make use of pure mechanical forces, such as gravity, elasticity, pressure of liquids and gases, could only be sought after by bewildered and ill-instructed people. But there are still other natural forces which are not reckoned among the purely moving forces,—heat, electricity, magnetism, light, chemical forces, all of which nevertheless stand in manifold relation to mechanical processes. There is hardly a natural process to be found which is not accompanied by mechanical actions, or from which mechanical work may not be derived. Here the question of a perpetual motion remained open; the decision of this question marks the progress of modern physics, regarding which I promised to address you.

In the case of the air-gun, the work to be accomplished in the propulsion of the ball was given by the arm of the man who pumped in the air. In ordinary firearms, the condensed mass of air which propels the bullet is obtained in a totally different manner, namely, by the combustion of the powder. Gunpowder is transformed by combustion for the most part into gaseous products, which endeavor to occupy a much larger space than that previously taken up by the volume of the powder. Thus you see, that, by the use of gunpowder, the work which the human arm must accomplish in the case of the air-gun is spared.

In the mightiest of our machines, the steam-engine, it is a strongly compressed aëriform body, water vapor, which, by its effort to expand, sets the machine in motion. Here also we do not condense the steam by means of an external mechanical force, but by communicating heat to a mass of water in a closed

boiler, we change this water into steam, which, in consequence of the limits of the space, is developed under strong pressure. In this case, therefore, it is the heat communicated which generates the mechanical force. The heat thus necessary for the machine we might obtain in many ways: the ordinary method is to procure it from the combustion of coal.

Combustion is a chemical process. A particular constituent of our atmosphere, oxygen, possesses a strong force of attraction, or, as it is named in chemistry, a strong affinity for the constituents of the combustible body, which affinity, however, in most cases can only exert itself at high temperatures. As soon as a portion of the combustible body, for example the coal, is sufficiently heated, the carbon unites itself with great violence to the oxygen of the atmosphere and forms a peculiar gas, carbonic acid, the same which we see foaming from beer and champagne. By this combination, light and heat are generated: heat is generally developed by any combination of two bodies of strong affinity for each other; and when the heat is intense enough, light appears. Hence in the steam-engine it is chemical processes and chemical forces which produce the astonishing work of these machines. In like manner the combustion of gunpowder is a chemical process, which in the barrel of the gun communicates living force to the bullet.

While now the steam-engine develops for us mechanical work out of heat, we can conversely generate heat by mechanical forces. A skillful blacksmith can render an iron wedge red-hot by hammering. The axles of our carriages must be protected by careful greasing from ignition through friction. And lately this property has been applied on a large scale. In some factories, where a surplus of water-power is at hand, this surplus is applied to cause a strong iron plate to rotate swiftly upon another, so that they become strongly heated by the friction. The heat so obtained warms the room, and thus a stove without fuel is provided. Now could not the heat generated by the plates be applied to a small steam-engine, which in its turn should be able to keep the rubbing plates in motion? The perpetual motion would thus be at length found. This question might be asked, and could not be decided by the older mathematico-mechanical investigations. I will remark beforehand, that the general law which I will lay before you answers the question in the negative.

By a similar plan, however, a speculative American set some time ago the industrial world of Europe in excitement. The magneto-electric machines often made use of in the case of rheumatic disorders are well known to the public. By imparting a swift rotation to the magnet of such a machine we obtain powerful currents of electricity. If those be conducted through wa-

ter, the latter will be reduced into its two components, oxygen and hydrogen. By the combustion of hydrogen, water is again generated. If this combustion takes place, not in atmospheric air, of which oxygen only constitutes a fifth part, but in pure oxygen, and if a bit of chalk be placed in the flame, the chalk will be raised to a white heat, and give us the sun-like Drummond's light. At the same time the flame develops a considerable quantity of heat. Our American proposed to utilize in this way the gases obtained from electrolytic decomposition, and asserted, that by the combustion a sufficient amount of heat was generated to keep a small steam-engine in action, which again drove his magneto-electric machine, decomposed the water, and thus continually prepared its own fuel. This would certainly have been the most splendid of all discoveries; a perpetual motion which, besides the force that kept it going, generated light like the sun, and warmed all around it. The matter was by no means badly cogitated. Each practical step in the affair was known to be possible; but those who at that time were acquainted with the physical investigations which bear upon this subject, could have affirmed, on first hearing the report, that the matter was to be numbered among the numerous stories of the fable-rich America; and indeed a fable it remained.

It is not necessary to multiply examples further. You will infer from those given, in what immediate connexion heat, electricity, magnetism, light, and chemical affinity, stand with mechanical forces.

Starting from each of these different manifestations of natural forces, we can set every other in motion, for the most part not in one way merely, but in many ways. It is here as with the weaver's web,—

> Where a step stirs a thousand threads,
> The shuttles shoot from side to side,
> The fibres flow unseen,
> And one shock strikes a thousand combinations.*

Now it is clear that if by any means we could succeed, through mechanical forces, as the above American professed to have done, to excite chemical, electrical, or other natural processes, which, by any circuit whatever, and without altering permanently the active masses in the machine, could produce mechanical force in greater quantity than that at first applied, a portion of the work thus gained might be made use of to keep the machine in motion, while the rest of the work might be applied to any other purpose whatever. The problem was to find, in the complicated

* "Wo ein Tritt tausend Fäden regt,
Die Schifflein herüber hinüber schiessen,
Die Fäden ungesehen fliessen,
Ein Schlag tausend Verbindungen schlägt."

net of reciprocal actions, a track through chemical, electrical, magnetical, and thermic processes, back to mechanical actions, which might be followed with a final gain of mechanical work: thus would the perpetual motion be found.

But, warned by the futility of former experiments, the public had become wiser. On the whole, people did not seek much after combinations which promised to furnish a perpetual motion, but the question was inverted. It was no more asked, how can I make use of the known and unknown relations of natural forces so as to construct a perpetual motion? but it was asked, if a perpetual motion be impossible, what are the relations which must subsist between natural forces? Everything was gained by this inversion of the question. The relations of natural forces rendered necessary by the above assumption, might be easily and completely stated. It was found that all known relations of forces harmonize with the consequences of that assumption, and a series of unknown relations were discovered at the same time, the correctness of which remained to be proved. If a single one of them could be proved false, then a perpetual motion would be possible.

The first who endeavored to travel this way was a Frenchman named Carnot, in the year 1824. In spite of a too limited conception of his subject, and an incorrect view as to the nature of heat, which led him to some erroneous conclusions, his experiment was not quite unsuccessful. He discovered a law which now bears his name, and to which I will return further on.

His labors remained for a long time without notice, and it was not till eighteen years afterwards, that is, in 1842, that different investigators in different countries, and independent of Carnot, laid hold of the same thought. The first who saw truly the general law here referred to, and expressed it correctly, was a German physician, J. R. Mayer of Heilbronn, in the year 1842. A little later, in 1843, a Dane named Colding, presented a memoir to the Academy of Copenhagen, in which the same law found utterance, and some experiments were described for its further corroboration. In England, Joule began about the same time to make experiments having reference to the same subject. We often find, in the case of questions to the solution of which the development of science points, that several heads, quite independent of each other, generate exactly the same series of reflections.*

* The following extract is taken from a lecture by Mr. Grove, delivered at the London Institution on the 19th of January, 1842:—

"Light, heat, electricity, magnetism, motion, and chemical affinity, are all convertible material affections; assuming any one as a cause, one of the others will be the effect. Thus heat may be said to produce electricity, electricity to produce heat; magnetism to produce electricity, electricity magnetism; and so of the rest. Cause and effect, therefore, in their relation to such forces, are words solely of conven-

I myself, without being acquainted with either Mayer or Colding, and having first made the acquaintance of Joule's experiments at the end of my investigation, followed the same path. I endeavored to ascertain all the relations between the different natural processes, which followed from our regarding them from the above point of view. My inquiry was made public in 1847, in a small pamphlet bearing the title, "On the Conservation of Force."*

Since that time the interest of the scientific public for this subject has gradually augmented, particularly in England, of which I had an opportunity of convincing myself during a visit last summer. A great number of the essential consequences of the above manner of viewing the subject, the proof of which was wanting when the first theoretic notions were published, have since been confirmed by experiment, particularly by those of Joule; and during the last year the most eminent physicist of France, Regnault, has adopted the new mode of regarding the question, and by fresh investigations on the specific heat of gases has contributed much to its support. For some important consequences the experimental proof is still wanting, but the number of confirmations is so predominant, that I have not deemed it too early to bring the subject before even a non-scientific audience.

How the question has been decided you may already infer from what has been stated. In the series of natural processes there is no circuit to be found, by which mechanical force can be gained without a corresponding consumption. The perpetual motion remains impossible. Our reflections, however, gain thereby a higher interest.

We have thus far regarded the development of force by natural processes, only in its relation to its usefulness to man, as mechanical force. You now see that we have arrived at a general law, which holds good wholly independent of the application which man makes of natural forces; we must therefore make the expression of our law correspond to this more general significance. It is in the first place clear, that the work which, by any natural process whatever, is performed under favorable con-

ience: we are totally unacquainted with the generating power of each and all of them, and probably shall ever remain so: we can only ascertain the normal of their action: we must humbly refer their causation to one omnipresent influence, and content ourselves with studying their effects, and developing by experiment their mutual relations."

"I have long held an opinion," says Mr. Faraday in 1845, "almost amounting to conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have a common origin, or in other words, are so directly related and mutually dependent, that they are convertible one into another."—Tr.

* A translation of this most important essay appears in the Scientific Memoirs, new series, p. 114.—J. T.

ditions by a machine, and which may be measured in the way already indicated, may be used as a measure of force common to all. Further, the important question arises, if the quantity of force cannot be augmented except by corresponding consumption, can it be diminished or lost? For the purposes of our machines it certainly can, if we neglect the opportunity to convert natural processes to use, but as investigation has proved, not for nature as a whole.

In the collision and friction of bodies against each other, the mechanics of former years assumed simply that living force was lost. But I have already stated that each collision and each act of friction generates heat; and, moreover, Joule has established by experiment the important law, that for every foot-pound of force which is lost a definite quantity of heat is always generated, and that when work is performed by the consumption of heat, for each foot-pound thus gained a definite quantity of heat disappears. The quantity of heat necessary to raise the temperature of a pound of water a degree of the Centigrade thermoneter, corresponds to a mechanical force by which a pound weight would be raised to the height of 1350 feet: we name this quantity the mechanical equivalent of heat. I may mention here that these facts conduct of necessity to the conclusion, that heat is not, as was formerly imagined, a fine imponderable substance, but that, like light, it is a peculiar vibratory motion of the ultimate particles of bodies. In collision and friction, according to this manner of viewing the subject, the motion of the mass of a body which is apparently lost is converted into a motion of the ultimate particles of the body; and conversely, when mechanical force is generated by heat, the motion of the ultimate particles is converted into a motion of the mass.

Chemical combinations generate heat, and the quantity of this heat is totally independent of the time and steps through which the combination has been effected, provided that other actions are not at the same time brought into play. If, however, mechanical work is at the same time accomplished, as in the case of the steam-engine, we obtain as much less heat as is equivalent to this work. The quantity of work produced by chemical force is in general very great. A pound of the purest coal gives, when burnt, sufficient heat to raise the temperature of 8086 lbs. of water one degree of the Centigrade thermometer; from this we can calculate that the magnitude of the chemical force of attraction between the particles of a pound of coal and the quantity of oxygen that corresponds to it, is capable of lifting a weight of 100 pounds to a height of twenty miles. Unfortunately in our steam-engines we have hitherto been able to gain only the smallest portion of this work, the greater part being lost in the shape of heat. The best expansive engines give back as

mechanical work only eighteen per cent of the heat generated by the fuel.

From a similar investigation of all the other known physical and chemical processes, we arrive at the conclusion, that nature, as a whole, possesses a store of force which cannot in any way be either increased or diminished, and that therefore the quantity of force in nature is just as eternal and unalterable as the quantity of matter. Expressed in this form, I have named the general law "The Principle of the Conservation of Force."

We cannot create mechanical force, but we may help ourselves from the general storehouse of nature. The brook and the wind, which drive our mills, the forest and the coal-bed, which supply our steam-engines and warm our rooms, are to us the bearers of a small portion of the great natural supply which we draw upon for our purposes, and the actions of which we can apply as we think fit. The possessor of a mill claims the gravity of the descending rivulet, or the living force of the moving wind, as his possession. These portions of the store of nature are what give his property its chief value.

Further, from the fact that no portion of force can be absolutely lost, it does not follow that a portion may not be inapplicable to human purposes. In this respect the inferences drawn by William Thomson from the law of Carnot are of importance. This law, which was discovered by Carnot during his endeavors to ascertain the relations between heat and mechanical force, —which, however, by no means belongs to the necessary consequences of the conservation of force, and which Clausius was the first to modify in such a manner that it no longer contradicted the above general law,—expresses a certain relation between the compressibility, the capacity for heat, and the expansion by heat, of all bodies. It is not yet considered as actually proved, but some remarkable deductions having been drawn from it and afterwards proved to be facts by experiment, it has attained thereby a great degree of probability. Besides the mathematical form in which the law was first expressed by Carnot, we can give it the following more general expression:—"Only when heat passes from a warmer to a colder body, and even then only partially, can it be converted into mechanical work."

The heat of a body which we cannot cool further, cannot be changed into another form of force; into the electric or chemical force, for example. Thus in our steam-engines we convert a portion of the heat of the glowing coal into work, by permitting it to pass to the less warm water of the boiler. If, however, all the bodies in nature had the same temperature, it would be impossible to convert any portion of their heat into mechanical work. According to this we can divide the total force store of the universe into two parts, one of which is heat, and must con-

tinue to be such; the other, to which a portion of the heat of the warmer bodies, and the total supply of chemical, mechanical, electrical, and magnetical forces belong, is capable of the most varied changes of form, and constitutes the whole wealth of change which takes place in nature.

But the heat of the warmer bodies strives perpetually to pass to bodies less warm by radiation and conduction, and thus to establish an equilibrium of temperature. At each motion of a terrestrial body a portion of mechanical force passes by friction or collision into heat, of which only a part can be converted back again into mechanical force. This is also generally the case in every electrical and chemical process. From this it follows, that the first portion of the store of force, the unchangeable heat, is augmented by every natural process, while the second portion, mechanical, electrical, and chemical force, must be diminished; so that if the universe be delivered over to the undisturbed action of its physical processes, all force will finally pass into the form of heat, and all heat come into a state of equilibrium. Then all possibility of a further change would be at an end, and the complete cessation of all natural processes must set in. The life of men, animals, and plants, could not of course continue if the sun had lost his high temperature, and with it his light,—if all the components of the earth's surface had closed those combinations which their affinities demand. In short, the universe from that time forward would be condemned to a state of eternal rest.

These consequences of the law of Carnot are of course only valid, provided that the law, when sufficiently tested, proves to be universally correct. In the mean time there is little prospect of the law being proved incorrect. At all events we must admire the sagacity of Thomson, who, in the letters of a long-known little mathematical formula, which only speaks of the heat, volume and pressure of the bodies, was able to discern consequences which threatened the universe, though certainly after an infinite period of time, with eternal death.

I have already given you notice that our path lay through a thorny and unrefreshing field of mathematico-mechanical developments. We have now left this portion of our road behind us. The general principle which I have sought to lay before you has conducted us to a point from which our view is a wide one, and aided by this principle, we can now at pleasure regard this or the other side of the surrounding world, according as our interest in the matter leads us. A glance into the narrow laboratory of the physicist, with its small appliances and complicated abstractions, will not be so attractive as a glance at the wide heaven above us, the clouds, the rivers, the woods, and the living beings around us. While regarding the laws which have been deduced

from the physical processes of terrestrial bodies as applicable also to the heavenly bodies, let me remind you that the same force, which, acting at the earth's surface, we call gravity (*Schwere*), acts as gravitation in the celestial spaces, and also manifests its power in the motion of the immeasurably distant double stars which are governed by exactly the same laws as those subsisting between the earth and moon; that therefore the light and heat of terrestrial bodies do not in any way differ essentially from those of the sun, or of the most distant fixed star; that the meteoric stones which sometimes fall from external space upon the earth are composed of exactly the same simple chemical substances as those with which we are acquainted. We need therefore feel no scruple in granting that general laws, to which all terrestrial natural processes are subject, are also valid for other bodies than the earth. We will therefore make use of our law to glance over the household of the universe with respect to the store of force capable of action which it possesses.

A number of singular peculiarities in the structure of our planetary system, indicate that it was once a connected mass with a uniform motion of rotation. Without such an assumption it is impossible to explain why all the planets move in the same direction round the sun, why they all rotate in the same direction round their axes, why the planes of their orbits, and those of their satellites and rings, all nearly coincide, why all their orbits differ but little from circles, and much besides. From these remaining indications of a former state, astronomers have shaped an hypothesis regarding the formation of our planetary system, which, although from the nature of the case it must ever remain an hypothesis, still in its special traits is so well supported by analogy, that it certainly deserves our attention, and the more so, as this notion first found utterance in our own home and within the walls of this town.* It was Kant who, feeling great interest in the physical description of the earth and the planetary system, undertook the labor of studying the works of Newton, and as an evidence of the depth to which he had penetrated into the fundamental ideas of Newton, seized the notion that the same attractive force of all ponderable matter which now supports the motion of the planets, must also aforetime have been able to form from matter loosely scattered in space the planetary system. Afterwards, and independent of Kant, Laplace, the great author of the *Méeanique Céleste*, laid hold of the same thought, and introduced it among astronomers.

The commencement of our planetary system, including the sun, must, according to this, be regarded as an immense nebulous mass which filled the portion of space which is now occu-

* Königsberg.

pied by our system, far beyond the limits of Neptune, our most distant planet. Even now we perhaps see similar masses in the distant regions of the firmament, as patches of nebulæ, and nebulous stars; within our system also, comets, the zodiacal light, the corona of the sun during a total eclipse, exhibit remnants of a nebulous substance, which is so thin that the light of the stars passes through it unenfeebled and unrefracted. If we calculate the density of the mass of our planetary system, according to the above assumption, for the time when it was a nebulous sphere, which reached to the path of the outmost planet, we should find that it would require several cubic miles of such matter to weigh a single grain.

The general attractive force of all matter must, however, impel these masses to approach each other, and to condense, so that the nebulous sphere became incessantly smaller, by which, according to mechanical laws, a motion of rotation originally slow, and the existence of which must be assumed, would gradually become quicker and quicker. By the centrifugal force which must act most energetically in the neighborhood of the equator of the nebulous sphere, masses could from time to time be torn away, which afterwards would continue their courses separate from the main mass, forming themselves into single planets, or, similar to the great original sphere, into planets with satellites and rings, until finally the principal mass condensed itself into the sun. With regard to the origin of heat and light this view gives us no information.

When the nebulous chaos first separated itself from other fixed star masses, it must not only have contained all kinds of matter which was to constitute the future planetary system, but also, in accordance with our new law, the whole store of force which at one time must unfold therein its wealth of actions. Indeed in this respect an immense dower was bestowed in the shape of the general attraction of all the particles for each other. This force, which on the earth exerts itself as gravity, acts in the heavenly spaces as gravitation. As terrestrial gravity when it draws a weight downwards performs work and generates *vis viva*, so also the heavenly bodies do the same when they draw two portions of matter from distant regions of space towards each other.

The chemical forces must have been also present, ready to act; but as these forces can only come into operation by the most intimate contact of the different masses, condensation must have taken place before the play of chemical forces began.

Whether still further supply of force in the shape of heat was present at the commencement we do not know. At all events, by aid of the law of the equivalence of heat and work, we find in the mechanical forces existing at the time to which we refer,

so rich a source of heat and light, that there is no necessity whatever to take refuge in the idea of a store of these forces originally existing.* When through condensation of the masses their particles came into collision and clung to each other, the *vis viva* of their motion would be thereby annihilated, and must reappear as heat. Already in old theories it has been calculated that cosmical masses must generate heat by their collision, but it was far from anybody's thought to make even a guess at the amount of heat to be generated in this way. At present we can give definite numerical values with certainty.

Let us make this addition to our assumption; that, at the commencement, the density of the nebulous matter was a vanishing quantity as compared with the present density of the sun and planets; we can then calculate how much work has been performed by the condensation; we can further calculate how much of this work still exists in the form of mechanical force, as attraction of the planets towards the sun, and as *vis viva* of their motion, and find, by this, how much of the force has been converted into heat.

The result of this calculation† is, that only about the 454th part of the original mechanical force remains as such, and that the remainder, converted into heat, would be sufficient to raise a mass of water equal to the sun and planets taken together, not less than twenty-eight millions of degrees of the Centigrade scale. For the sake of comparison, I will mention that the highest temperature which we can produce by the oxyhydrogen blowpipe, which is sufficient to fuse and vaporize even platina, and which but few bodies can endure, is estimated at about 2000 C. degrees. Of the action of a temperature of twenty-eight millions of such degrees we can form no notion. If the mass of our entire system were pure coal, by the combustion of the whole of it only the 3500th part of the above quantity would be generated. This is also clear, that such a development of heat must have presented the greatest obstable to the speedy union of the masses, that the larger part of the heat must have been diffused by radiation into space, before the masses could form bodies possessing the present density of the sun and planets, and that these bodies must once have been in a state of fiery fluidity. This notion is corroborated by the geological phenomena of our planet; and with regard to the other planetary bodies, the flattened form of the sphere, which is the form of equilibrium of a fluid mass, is indicative of a former state of fluidity. If I thus permit an immense quantity of heat to disappear without compensation from our system, the principle of the conservation of force is not thereby invaded. Certainly for our planet it is lost, but not for

* No necessity for a "Fire-mist."—Tr.

† See note at the end.

the universe. It has proceeded outwards, and daily proceeds outwards into infinite space; and we know not whether the medium which transmits the undulations of light and heat, possesses an end where the rays must return, or whether they eternally pursue their way through infinitude.

The store of force at present possessed by our system is also equivalent to immense quantities of heat. If our earth were by a sudden shock brought to rest in her orbit,—which is not to be feared in the existing arrangement of our system—by such a shock a quantity of heat would be generated equal to that produced by the combustion of fourteen such earths of solid coal. Making the most unfavorable assumption as to its capacity for heat, that is, placing it equal to that of water, the mass of the earth would thereby be heated 11200 degrees: it would therefore be quite fused and for the most part reduced to vapor. If then the earth, after having been thus brought to rest, should fall into the sun, which of course would be the case, the quantity of heat developed by the shock would be four hundred times greater.

Even now from time to time such a process is repeated on a small scale. There can hardly be a doubt that meteors, fireballs, and meteoric stones are masses which belong to the universe, and before coming into the domain of our earth, moved like the planets round the sun. Only when they enter our atmosphere do they become visible and fall sometimes to the earth. In order to explain the emission of light by these bodies, and the fact that for some time after their descent they are very hot, the friction was long ago thought of which they experience in passing through the air. We can now calculate that a velocity of 3000 feet a second, supposing the whole of the friction to be expended in heating the solid mass, would raise a piece of meteoric iron 1000° C. in temperature, or, in other words, to a vivid red heat. Now the average velocity of the meteors seems to be thirty or forty times the above amount. To compensate this, however, the greater portion of the heat is doubtless carried away by the condensed mass of air which the meteor drives before it. It is known that bright meteors generally leave a luminous trail behind them, which probably consists of severed portions of the red-hot surfaces. Meteoric masses which fall to the earth often burst with a violent explosion, which may be regarded as a result of the quick heating. The newly-fallen pieces have been for the most part found hot, but not red-hot, which is easily explainable by the circumstance, that during the short time occupied by the meteor in passing through the atmosphere, only a thin superficial layer is heated to redness, while but a small quantity of heat has been able to penetrate to the interior of the mass. For this reason the red heat can speedily disappear.

Thus has the falling of the meteoric stone, the minute remnant of processes which seem to have played an important part in the formation of the heavenly bodies, conducted us to the present time, where we pass from the darkness of hypothetical views to the brightness of knowledge. In what we have said, however, all that is hypothetical is the assumption of Kant and Laplace, that the masses of our system were once distributed as nebulæ in space.

On account of the rarity of the case, we will still further remark in what close coincidence the results of science here stand with the earlier legends of the human family, and the forebodings of poetic fancy. The cosmogony of ancient nations generally commences with chaos and darkness.

Neither is the Mosaic tradition very divergent, particularly when we remember that that which Moses names heaven is different from the blue dome above us, and is synonymous with space, and that the unformed earth and the waters of the great deep, which were afterwards divided into waters above the firmament and waters below the firmament, resembled the chaotic components of the world.

Our earth bears still the unmistakable traces of its old fiery fluid condition. The granite formations of her mountains exhibit a structure, which can only be produced by the crystallization of fused masses. Investigation still shows that the temperature in mines and borings increases as we descend; and if this increase is uniform, at the depth of fifty miles a heat exists sufficient to fuse all our minerals.* Even now our volcanoes project from time to time mighty masses of fused rocks from their interior, as a testimony of the heat which exists there. But the cooled crust of the earth has already become so thick, that, as may be shown by calculations of its conductive power, the heat coming to the surface from within, in comparison with that reaching the earth from the sun, is exceedingly small, and increases the temperature of the surface only about $\frac{1}{30}$th of a degree Centigrade; so that the remnant of the old store of force which is enclosed as heat within the bowels of the earth, has a sensible influence upon the processes at the earth's surface only through the instrumentality of volcanic phenomena. These processes owe their power almost wholly to the action of other heavenly bodies, particularly to the light and heat of the sun, and partly also, in the case of the tides, to the attraction of the sun and moon.

Most varied and numerous are the changes which we owe to the light and heat of the sun. The sun heats our atmosphere irregu-

* This is not probable. The greater density and consequent better conductivity of the mass, and the elevation of the point of fusion by pressure, established by the researches of Messrs. Hopkins and Fairbairn, would throw the region of liquidity deeper.—Tr.

larly, the warm rarefied air ascends, while fresh cool air flows from the sides to supply its place: in this way winds are generated. This action is most powerful at the equator, the warm air of which incessantly flows in the upper regions of the atmosphere towards the poles; while just as persistently at the earth's surface, the trade-wind carries new and cool air to the equator. Without the heat of the sun, all winds must of necessity cease. Similar currents are produced by the same cause in the waters of the sea. Their power may be inferred from the influence which in some cases they exert upon climate. By them, the warm water of the Antilles is carried to the British Isles, and confers upon them a mild uniform warmth, and rich moisture; while, through similar causes, the floating ice of the North Pole is carried to the coast of Newfoundland and produces raw cold. Further, by the heat of the sun a portion of the water is converted into vapor, which rises in the atmosphere, is condensed to clouds, or falls in rain and snow upon the earth, collects in the form of springs, brooks and rivers, and finally reaches the sea again, after having eroded the rocks, carried away loose earth, and thus performed its part in the geologic changes of the globe; perhaps, besides all this, it has driven our water-mill upon its way. If the heat of the sun were withdrawn, there would remain only a single motion of water, namely, the tides, which are produced by the attraction of the sun and moon.

How is it, now, with the motions and the work of organic beings. To the builders of the automata of the last century, men and animals appeared as clockwork which was never wound up, and created the force which they exerted out of nothing. They did not know how to establish a connexion between the nutriment consumed and the work generated. Since, however, we have learned to discern in the steam-engine this origin of mechanical force, we must inquire whether something similar does not hold good with regard to men. Indeed, the continuation of life is dependent on the consumption of nutritive materials: these are combustible substances, which, after digestion and being passed into the blood, actually undergo a slow combustion, and finally enter into almost the same combinations with the oxygen of the atmosphere that are produced in an open fire. As the quantity of heat generated by combustion is independent of the duration of the combustion and the steps in which it occurs, we can calculate from the mass of the consumed material how much heat, or its equivalent work, is thereby generated in an animal body. Unfortunately, the difficulty of the experiments is still very great; but within those limits of accuracy which have been as yet attainable, the experiments show that the heat generated in the animal body corresponds to the amount which would be generated by the chemical processes. The animal body therefore does

not differ from the steam-engine, as regards the manner in which it obtains heat and force, but does differ from it in the manner in which the force gained is to be made use of. The body is, besides, more limited than the machine in the choice of its fuel; the latter could be heated with sugar, with starch-flour, and butter, just as well as with coal or wood; the animal body must dissolve its materials artificially, and distribute them through its system; it must, further, perpetually renew the used-up materials of its organs, and as it cannot itself create the matter necessary for this, the matter must come from without. Liebig was the first to point out these various uses of the consumed nutriment. As material for the perpetual renewal of the body, it seems that certain definite albuminous substances which appear in plants, and form the chief mass of the animal body, can alone be used. They form only a portion of the mass of nutriment taken daily; the remainder, sugar, starch, fat, are really only materials for warming, and are perhaps not to be superseded by coal, simply because the latter does not permit itself to be dissolved.

If, then, the processes in the animal body are not in this respect to be distinguished from inorganic processes, the question arises, whence comes the nutriment which constitutes the source of the body's force? The answer is, from the vegetable kingdom; for only the material of plants, or the flesh of plant-eating animals, can be made use of for food. The animals which live on plants occupy a mean position between carnivorous animals, in which we reckon man, and vegetables, which the former could not make use of immediately as nutriment. In hay and grass the same nutritive substances are present as in meal and flour, but in less quantity. As, however, the digestive organs of man are not in a condition to extract the small quantity of the useful from the great excess of the insoluble, we submit, in the first place, these substances to the powerful digestion of the ox, permit the nourishment to store itself in the animal's body, in order in the end to gain it for ourselves in a more agreeable and useful form. In answer to our question, therefore, we are referred to the vegetable world. Now when what plants take in and what they give out are made the subjects of investigation, we find that the principal part of the former consists in the products of combustion which are generated by the animal. They take the consumed carbon given off in respiration, as carbonic acid, from the air, the consumed hydrogen as water, the nitrogen in its simplest and closest combination as ammonia; and from these materials, with the assistance of small ingredients which they take from the soil, they generate anew the compound combustible substances, albumen, sugar, oil, on which the animal subsists. Here, therefore, is a circuit which appears to be a perpetual store of

force. Plants prepare fuel and nutriment, animals consume these, burn them slowly in their lungs, and from the products of combustion the plants again derive their nutriment. The latter is an eternal source of chemical, the former of mechanical forces. Would not the combination of both organic kingdoms produce the perpetual motion? We must not conclude hastily: further inquiry shows, that plants are capable of producing combustible substances only when they are under the influence of the sun. A portion of the sun's rays exhibits a remarkable relation to chemical forces,—it can produce and destroy chemical combinations; and these rays, which for the most part are blue or violet, are called therefore chemical rays. We make use of their action in the production of photographs. Here compounds of silver are decomposed at the place where the sun's rays strike them. The same rays overpower in the green leaves of plants the strong chemical affinity of the carbon of the carbonic acid for oxygen, give back the latter free to the atmosphere, and accumulate the other, in combination with other bodies, as woody fibre, starch, oil, or resin. These chemically active rays of the sun disappear completely as soon as they encounter the green portions of the plants, and hence it is that in daguerreotype images the green leaves of plants appear uniformly black. Inasmuch as the light coming from them does not contain the chemical rays, it is unable to act upon the silver compounds.

Hence a certain portion of force disappears from the sunlight, while combustible substances are generated and accumulated in plants; and we can assume it as very probable, that the former is the cause of the latter. I must indeed remark, that we are in possession of no experiments from which we might determine whether the *vis viva* of the sun's rays which have disappeared corresponds to the chemical forces accumulated during the same time; and as long as these experiments are wanting, we cannot regard the stated relation as a certainty. If this view should prove correct, we derive from it the flattering result, that all force, by means of which our bodies live and move, finds its source in the purest sunlight; and hence we are all, in point of nobility, not behind the race of the great monarch of China, who heretofore alone called himself Son of the Sun. But it must also be conceded, that our lower fellow-beings, the frog and leech, share the same etherial origin, as also the whole vegetable world, and even the fuel which comes to us from the ages past, as well as the youngest offspring of the forest with which we heat our stoves and set our machines in motion.

You see, then, that the immense wealth of ever-changing meteorological, climatic, geological, and organic processes of our earth are almost wholly preserved in action by the light and heat-giving rays of the sun; and you see in this a remarkable

example, how Proteus-like the effects of a single cause, under altered external conditions, may exhibit itself in nature. Besides these, the earth experiences an action of another kind from its central luminary, as well as from its satellite the moon, which exhibits itself in the remarkable phenomenon of the ebb and flow of the tide.

Each of these bodies excites, by its attraction upon the waters of the sea, two gigantic waves, which flow in the same direction round the world, as the attracting bodies themselves apparently do. The two waves of the moon, on account of her greater nearness, are about $3\frac{1}{2}$ times as large as those excited by the sun. One of these waves has its crest on the quarter of the earth's surface which is turned towards the moon, the other is at the opposite side. Both these quarters possess the flow of the tide, while the regions which lie between have the ebb. Although in the open sea the height of the tide amounts to only about three feet, and only in certain narrow channels, where the moving water is squeezed together, rises to thirty feet, the might of the phenomena is nevertheless manifest from the calculation of Bessel, according to which a quarter of the earth covered by the sea possesses, during the flow of the tide, about 25,000 cubic miles of water more than during the ebb, and that therefore such a mass of water must, in $6\frac{1}{4}$ hours, flow from one quarter of the earth to the other.

The phenomena of the ebb and flow, as already recognized by Mayer, combined with the law of the conservation of force, stands in remarkable connexion with the question of the stability of our planetary system. The mechanical theory of the planetary motions discovered by Newton teaches, that if a solid body in absolute *vacuo*, attracted by the sun, move around him in the same manner as the planets, this motion will endure unchanged through all eternity.

Now we have actually not only one, but several such planets, which move around the sun, and by their mutual attraction create little changes and disturbances in each other's paths. Nevertheless Laplace, in his great work, the *Mécanique Céleste*, has proved that in our planetary system all these disturbances increase and diminish periodically, and can never exceed certain limits, so that by this cause the eternal existence of the planetary system is unendangered.

But I have already named two assumptions which must be made: first, that the celestial spaces must be absolutely empty; and secondly, that the sun and planets must be solid bodies. The first is at least the case as far as astronomical observations reach, for they have never been able to detect any retardation of the planets, such as would occur if they moved in a resisting medium. But on a body of less mass, the comet of Encke,

changes are observed of such a nature: this comet describes ellipses round the sun which are becoming gradually smaller. If this kind of motion, which certainly corresponds to that through a resisting medium, be actually due to the existence of such a medium, a time will come when the comet will strike the sun; and a similar end threatens all the planets, although after a time, the length of which baffles our imagination to conceive of it. But even should the existence of a resisting medium appear doubtful to us, there is no doubt that the planets are not wholly composed of solid materials which are inseparably bound together. Signs of the existence of an atmosphere are observed on the Sun, on Venus, Mars, Jupiter, and Saturn. Signs of water and ice upon Mars; and our earth has undoubtedly a fluid portion on its surface, and perhaps a still greater portion of fluid within it. The motions of the tides, however, produce friction, all friction destroys *vis viva*, and the loss in this case can only affect the *vis viva* of the planetary system. We come thereby to the unavoidable conclusion, that every tide, although with infinite slowness, still with certainty, diminishes the store of mechanical force of the system; and as a consequence of this, the rotation of the planets in question round their axes must become more slow, they must therefore approach the sun, or their satellites must approach them. What length of time must pass before the length of our day is diminished one second by the action of the tides cannot be calculated, until the height and time of the tide in all portions of the ocean are known. This alteration, however, takes place with extreme slowness, as is known by the consequences which Laplace has deduced from the observations of Hipparchus, according to which, during a period of 2000 years, the duration of the day has not been shortened by the $\frac{1}{3\,0\,0}$th part of a second. The final consequence would be, but after millions of years, if in the mean time the ocean did not become frozen, that one side of the earth would be constantly turned towards the sun, and enjoy a perpetual day, whereas the opposite side would be involved in eternal night. Such a position we observe in our moon with regard to the earth, and also in the case of the satellites as regards their planets; it is, perhaps, due to the action of the mighty ebb and flow to which these bodies, in the time of their fiery fluid condition, were subjected.

I would not have brought forward these conclusions, which again plunge us in the most distant future, if they were not unavoidable. Physico-mechanical laws are, as it were, the telescopes of our spiritual eye, which can penetrate into the deepest night of time, past and to come.

Another essential question as regards the future of our planetary system has reference to its future temperature and illumi-

nation. As the internal heat of the earth has but little influence on the temperature of the surface, the heat of the sun is the only thing which essentially affects the question. The quantity of heat falling from the sun during a given time upon a given portion of the earth's surface may be measured, and from this it can be calculated how much heat in a given time is sent out from the entire sun. Such measurements have been made by the French physicist Pouillet, and it has been found that the sun gives out a quantity of heat per hour equal to that which a layer of the densest coal 10 feet thick would give out by its combustion; and hence in a year a quantity equal to the combustion of a layer of 17 miles. If this heat were drawn uniformly from the entire mass of the sun, its temperature would only be diminished thereby $1\frac{1}{3}$d of a degree Centigrade per year, assuming its capacity for heat to be equal to that of water. These results can give us an idea of the magnitude of the emission, in relation to the surface and mass of the sun; but they cannot inform us whether the sun radiates heat as a glowing body, which since its formation has its heat accumulated within it, or whether a new generation of heat by chemical processes takes place at the sun's surface. At all events the law of the conservation of force teaches us that no process analogous to those known at the surface of the earth, can supply for eternity an inexhaustible amount of light and heat to the sun. But the same law also teaches that the store of force at present existing, as heat, or as what may become heat, is sufficient for an immeasurable time. With regard to the store of chemical force in the sun, we can form no conjecture, and the store of heat there existing can only be determined by very uncertain estimations. If, however, we adopt the very probable view, that the remarkably small density of so large a body is caused by its high temperature, and may become greater in time, it may be calculated that if the diameter of the sun were diminished only the ten-thousandth part of its present length, by this act a sufficient quantity of heat would be generated to cover the total emission for 2100 years. Such a small change besides it would be difficult to detect even by the finest astronomical observations.

Indeed, from the commencement of the period during which we possess historic accounts, that is, for a period of about 4000 years, the temperature of the earth has not sensibly diminished. From these old ages we have certainly no thermometric observations, but we have information regarding the distribution of certain cultivated plants, the vine, the olive tree, which are very sensitive to changes of the mean annual temperature, and we find that these plants at the present moment have the same limits of distribution that they had in the times of Abraham and Homer; from which we may infer backwards the constancy of the climate.

In opposition to this it has been urged, that here in Prussia the German knights in former times cultivated the vine, cellared their own wine and drank it, which is no longer possible. From this the conclusion has been drawn, that the heat of our climate has diminished since the time referred to. Against this, however, Dove has cited the reports of ancient chroniclers, according to which, in some peculiarly hot years, the Prussian grape possessed somewhat less than its usual quantity of acid. The fact also speaks not so much for the climate of the country as for the throats of the German drinkers.

But even though the force store of our planetary system is so immensely great, that by the incessant emission which has occurred during the period of human history it has not been sensibly diminished, even though the length of the time which must flow by, before a sensible change in the state of our planetary system occurs, is totally incapable of measurement, still the inexorable laws of mechanics indicate that this store of force, which can only suffer loss and not gain, must be finally exhausted. Shall we terrify ourselves by this thought? Men are in the habit of measuring the greatness and the wisdom of the universe by the duration and the profit which it promises to their own race; but the past history of the earth already shows what an insignificant moment the duration of the existence of our race upon it constitutes. A Nineveh vessel, a Roman sword awakes in us the conception of grey antiquity. What the museums of Europe show us of the remains of Egypt and Assyria we gaze upon with silent astonishment, and despair of being able to carry our thoughts back to a period so remote. Still must the human race have existed for ages, and multiplied itself before the pyramids of Nineveh could have been erected. We estimate the duration of human history at 6000 years; but immeasurable as this time may appear to us, what is it in comparison with the time during which the earth carried successive series of rank plants and mighty animals, and no men; during which in our neighborhood the amber-tree bloomed, and dropped its costly gum on the earth and in the sea; when in Siberia, Europe and North America groves of tropical palms flourished; where gigantic lizards, and after them elephants, whose mighty remains we still find buried in the earth, found a home? Different geologists, proceeding from different premises, have sought to estimate the duration of the above creative period, and vary from a million to nine million years. And the time during which the earth generated organic beings is again small when we compare it with the ages during which the world was a ball of fused rocks. For the duration of its cooling from 2000° to 200° Centigrade, the experiments of Bishop upon basalt show that about 350 millions of years would be necessary. And with regard to

the time during which the first nebulous mass condensed into our planetary system, our most daring conjectures must cease. The history of man, therefore, is but a short ripple in the ocean of time. For a much longer series of years than that during which man has already occupied this world, the existence of the present state of inorganic nature favorable to the duration of man seems to be secured, so that for ourselves and for long generations after us we have nothing to fear. But the same forces of air and water, and of the volcanic interior, which produced former geological revolutions, and buried one series of living forms after another, act still upon the earth's crust. They more probably will bring about the last day of the human race than those distant cosmical alterations of which we have spoken, and perhaps force us to make way for new and more complete living forms, as the lizards and the mammoth have given place to us and our fellow-creatures which now exist.

Thus the thread which was spun in darkness by those who sought a perpetual motion has conducted us to a universal law of nature, which radiates light into the distant nights of the beginning and of the end of the history of the universe. To our own race it permits a long but not an endless existence; it threatens it with a day of judgment, the dawn of which is still happily obscured. As each of us singly must endure the thought of his death, the race must endure the same. But above the forms of life gone by, the human race has higher moral problems before it, the bearer of which it is, and in the completion of which it fulfills its destiny.

*Note to page* 205.—I must here explain the calculation of the heat which must be produced by the assumed condensation of the bodies of our system from scattered nebulous matter. The other calculations, the results of which I have mentioned, are to be found partly in J. R. Mayer's papers, partly in Joule's communications, and partly by aid of the known facts and method of science: they are easily performed.

The measure of the work performed by the condensation of the mass from a state of infinitely small density, is the potential of the condensed mass upon itself. For a sphere of uniform density of the mass M, and the radius R, the potential upon itself V—if we call the mass of the earth $m$, its radius $r$, and the intensity of gravity at its surface $g$,—has the value

$$V = \frac{3}{5} \cdot \frac{r^2 M^2}{Rm} \cdot g.$$

Let us regard the bodies of our system as such spheres, then the total work of condensation is equal to the sum of all their potentials on themselves. As, however, these potentials for different spheres are to each other as the quantity $\frac{M^2}{R}$, they all vanish in comparison with the sun; even that of the greatest planet, Jupiter, is only about the one hundred-thousandth part of that of the sun; in the calculation, therefore, it is only necessary to introduce the latter.

To elevate the temperature of a mass M of the specific heat $\sigma$, $t$ degrees, we need a quantity of heat equal to $M\sigma t$; this corresponds, when $Ag$ represents the mechanical equivalent of the unit of heat, to the work $AgM\sigma t$. To find the elevation of temperature produced by the condensation of the mass of the sun, let us set

$$AgM\sigma t = V;$$

we have then

$$t = \frac{3}{5} \cdot \frac{r^2 M}{A \,.\, R \,.\, m \,.\, \sigma}.$$

For a mass of water equal to the sun we have $\sigma = 1$; then the calculation with the known values of A, M, R, $m$, and $r$, gives

$$t = 28611000° \text{ Cent.}$$

The mass of the sun is 738 times greater than that of all the planets taken together; if, therefore, we desire to make the water-mass equal to that of the entire system, we must multiply the value of $t$ by the fraction $\frac{738}{739}$, which makes hardly a sensible alteration in the result.

When a spherical mass of the radius R condenses more and more to the radius $R_1$, the elevation of temperature thereby produced is

$$\vartheta = \frac{3}{5} \cdot \frac{r^2 M}{A \,.\, m\sigma}\left(\frac{1}{R_1} - \frac{1}{R_0}\right), \quad \text{or} \quad = \frac{3}{5} \cdot \frac{r^2 M}{A R_1 m\sigma}\left(1 - \frac{R_1}{R_0}\right).$$

Supposing, then, the mass of the planetary system to be at the commencement, not a sphere of infinite radius, but limited, say of the radius of the path of Neptune, which is six thousand times greater than the radius of the sun, the magnitude $\frac{R_1}{R_0}$ will then be equal to $\frac{1}{6000}$, and the above value of $t$ would have to be diminished by this inconsiderable amount.

From the same formula, we can deduce that a diminution of $\frac{1}{10000}$ of the radius of the sun would generate work in a water mass equal to the sun, equivalent to 2861 degrees Centigrade. And as, according to Pouillet, a quantity of heat corresponding to $1\frac{1}{4}$ degree is lost annually in such a mass, the condensation referred to would cover the loss for 2289 years.

If the sun, as seems probable, be not everywhere of the same density, but is denser at the centre than near the surface, the potential of its mass and the corresponding quantity of heat will be still greater.

Of the now remaining mechanical forces, the *vis viva* of the rotation of the heavenly bodies round their own axes is, in comparison with the other quantities, very small, and may be neglected. The *vis viva* of the motion of revolution round the sun, if $\mu$ be the mass of a planet, $\varrho$ its distance from the sun, is

$$L = \frac{gr^2 M\mu}{m}\left(\frac{1}{R} - \frac{1}{2\varrho}\right).$$

Omitting the quantity $\frac{1}{2\varrho}$ as very small compared with $\frac{1}{R}$, and dividing by the above value of V, we obtain $\frac{L}{V} = \frac{5}{3}\frac{\mu}{M}$.

The mass of all the planets together is $\frac{1}{738}$ of the mass of the sun, hence the value of L for the entire system is $L = \frac{1}{453} \,.\, V$.

ART. XVI.—*On the Formation of Craters, and the Nature of the Liquidity of Lavas;** by G. POULETT SCROPE, Esq., M.P., F.R.S., F.G.S.

II. *The nature of the liquidity of lavas.*—So much for that branch of my subject,—the formation of cones and craters. I wish now to ask attention to some circumstances respecting the mode of emission and nature of the lavas that proceed from them. I have already spoken of the comparatively tranquil manner in which some lava-streams are seen to well out from the flank of a volcano, or its summit, and the probability that differences in the liquidity or viscosity of the heated matter at the time of its efflux may occasion corresponding differences in the character of the phenomena. Observation confirms this expectation; and it has been remarked, that the very liquid and vitrified lavas, such as those of Kilauea and Bourbon, are poured out more or less tranquilly without any very violent explosions, their imprisoned vapors evidently escaping with comparative ease, while the more viscous and ultimately stony lavas, possessing a minor degree of liquidity, and consequently not allowing so easy a passage to the vapors that rise through, and struggle to escape from them, are protruded with fiercer explosive bursts, and the ejection of far greater quantities of scoria and other fragmentary matters.

This observation, coupled with other reasons to which I shall presently advert, led me to an opinion expressed in the works above referred to, that the ordinary crystalline or granular lavas (making exception of the vitreous varieties), although at a white heat at the moment of their emission from a volcanic vent, are not in a state of complete fusion; that a large proportion, at least, if not all, of the crystalline or granular particles of which, when cooled and consolidated, they appear composed, are already formed and solid, their mobility being aided by the intimate dissemination through the mass of a minute but appreciable quantity of some fluid,—in all probability water,—which is prevented from expanding wholly into vapor by the pressure to which it is subjected while within the volcanic vent, or in the interior of the current, until that pressure is sufficiently reduced to allow of its expansion into bubbles, or its escape through pores or cracks, by which it passes into the open air from the surface of the intumescent lava.

I was strengthened in this opinion by several concurrent considerations:—

1. If all lavas are (as they are usually supposed to be) in a state of complete fusion when they issue from a volcano, how is

* Concluded from vol. xxiii, p. 359.

it that they do not all present the same glassy texture which is seen in some, the obsidians, pitchstones, and pumiceous lavas especially, and in the ropy, cavernous, filamentous basalts of Kilauea, Iceland, and Bourbon, and which these very crystalline and stony lavas themselves put on when melted under the blowpipe or in a furnace? The usual answer is, that the granular and crystalline texture is acquired subsequently to emission by slow cooling; and the experiments of Gregory Watt and Sir James Hall are cited in support of this assertion. In the present day, probably the process by which Messrs. Chance & Co., of Birmingham, devitrify a mass of fused basalt (from the Rowley rag, near Dudley) by causing it to cool slowly in an "annealing furnace," would be considered as a strong confirmatory fact.

But there is no fact more certain than this, that the superficial portions, at least, of a lava-current flowing in the open air, do not cool slowly. On the contrary, they are rapidly, I might say instantaneously, upon their exposure, consolidated and cooled down to a temperature which permits them to be handled and even walked upon without damage. How is it that this scoriform crust, or the solid cakes and slabs which so instantly form upon every exposed surface of lava, nay, even the scoria which is tossed up in a liquid state by the eruptive jets, and harden while yet in the air before they fall, exhibit on fracture no glassy texture, but much the same earthy or stony grain, and occasionally crystals of considerable size in the solid matter separating their cellular cavities, as is found in the interior of the current which is known to have cooled very slowly? How is it that some lava currents are stony throughout, others vitreous throughout, as, for example, some of the large pumice-streams of Lipari, Iceland, and the Andes?

I have recently visited the manufactory of the Messrs Chance, at Oldbury, near Birmingham, for the purpose of examining the mode in which the basalt used there (and which is the same upon which Mr. Gregory Watt experimented) conducts itself in their furnaces, and I found, that when the liquid and fused contents of a furnace at a white heat is poured out upon a brick or other floor into the open air, so as to represent a stream of lava flowing out of a volcanic vent, it consolidates throughout, whatever its bulk, into a homogeneous and purely vitreous black obsidian, in fact, an absolute glass, with a conchoidal fracture and sharp cutting edges. It is only when made to consolidate very slowly in an oven kept at a high temperature for some days, that it assumes the deadened and semi-crystalline texture of the manufactured article.

If this process be interrupted, it is found to have commenced by the formation, at numerous points within the vitreous mass, of globular concretions about the size of a small pea, of a lighter color than the base, and having a pearly lustre and radiated

structure. The multiplication and confusion of these crystallites or sphærulites ultimately destroy the glassy character of the substance altogether, and give to it a pearly semi-crystalline texture, without, however, restoring the far more crystalline aspect of the basaltic rock. A similar change may be often observed to have taken place in nature among the vitreous lavas, which pass into pearlstone and pitchstone by the formation of the same kind of sphærulitic concretions, and of course there is no question as to the complete state of fusion in which such lavas have been produced. But there is no trace of such a process in any of the ordinary earthy, and stony or crystalline and porphyritic lavas. I am not aware of a single current from either Etna or Vesuvius having ever exhibited, even on its most rapidly cooled surfaces, any passage into true obsidian, or sphærulitic pearlstone, or any portion of such vitrifactions. A pellicle, or glaze, of a semi-vitreous appearance coats the surface in some parts, or lines the cellular cavities; but it seems evident that the bulk of the matter could not have been at the time of its emission in that thoroughly fused condition which it assumes when melted in a furnace or under the blowpipe.

2. It struck me that temperature does not alone determine the fusion or liquefaction of substances; and that compression may prevent the liquefaction of a solid at a high temperature, just as it prevents the vaporization of a liquid, in the common experiment of boiling water at a lower temperature in a rarefied atmosphere. If so, the intense pressure to which heated lava must be subjected before it rises from the bowels of the earth to discharge itself on the surface, intensified by the reaction of its own expansive force from the confining surfaces, might perhaps prevent its complete fusion, however high the temperature.

3. I had long been impressed by the vast volumes of aqueous and other elastic vapors evidently discharged from every volcano in eruption, and to all appearance the chief agents in the expulsion of lavas from the bowels of the earth. That this vapor is liable to be developed in every part of the mass of lava is shown by the formation of vesicles throughout its substance wherever the pressure is so reduced as to permit their expansion; for instance, in the superficial portions of a current; and in some lava-currents throughout the entire mass.

The experiments of Mr. Knox, related in a paper read before the Royal Society in 1824,* had taught me that water in an appreciable quantity is mechanically combined with the elementary particles of all the crystalline rocks of igneous origin. The question, therefore, arose,— Might not the water thus intimately disseminated through a mass of crystalline lava, although at an intense temperature, remain unvaporized owing to the still greater

* Phil. Trans., 1825.

intensity of the pressure by which it is confined while yet within the bowels of the earth? and would it not under these circumstances exert an intense expansive force upon all the confining molecular or crystalline surfaces between which it lies, and thus occasion a tendency to separation among these solid particles whenever the compressing forces were relaxed, or the temperature increased sufficiently, so as to give a certain degree of mobility to these particles *inter se*, and an imperfect liquidity to the mass composed of them? And, supposing the intumescence thus occassioned to raise any portion of this semi-liquid matter into the open air, would not the instantaneous absorption of caloric from the contiguous particles, that must accompany the vaporization of this water, and its escape in bubbles or pores and through cracks, owing to the nearly absolute cessation of pressure, account for the sudden cooling down and *setting*, or consolidation, of the exposed surfaces, without having undergone complete fusion (except in the case of mere superficial films), notwithstanding their previous intense temperature, amounting even to a white heat?

This supposition seemed to me to account satisfactorily, not only for the absence of a vitreous texture even in superficial portions of many lava-streams, and their instantaneous consolidation on exposure, in cellular or porous slabs and cakes, but also for several other characteristics of igneous rocks, not easily to be reconciled with the idea of their having always issued from the earth in a state of absolute fusion; such, for example, as the cracked and vitrified aspect of the feldspar-crystals of many trachytes, the broken and dislocated appearance of the leucites, feldspars, and other crystals in many basalts; the frequent arrangement of their longest axes in the direction of the bed of the rock, that is, of the movement of the lava when liquefied; the finer grain often exhibited towards the tail or extremity of a current than at its source, the brecciated lavas which appear to have enveloped fragments in great number of the same material without any fusion even of their finest angles. So also might be explained the more or less spongy, porous, and loosely crystalline texture of many trachytes, and their disposition in thick beds or dome-shaped bosses, attesting their protrusion in a very imperfect state of liquidity, more resembling the intumescence of some kinds of dough in an oven than the fusion of metal in a furnace.

And here let me remark, that Dr. Daubeny, and some other writers on volcanic phenomena, have spoken of the vesicles or air-bladders in lavas, as being proofs of their having been in a state of complete fusion. But have the loaves baked in our ovens been in fusion? The comparison of a cellular scoria with a loaf or a French roll, will show that vesicles of precisely simi-

lar appearance to those of lava are producible in substances of a pasty consistence, which owe their liquidity to an aqueous vehicle, the heat applied being only sufficient to develop the contained gases. Other kinds of baked cakes are porous rather than cellular, and aptly represent the texture of the earthy and porous trachytic lavas.

*Plutonic rocks.*—This theory as to the nature of the liquidity of many lavas appeared to me to be so reasonable, that I proceeded to examine its applicability to the still more generally crystalline plutonic rocks, from the alteration of which by heat lavas are usually supposed to derive. I asked myself, what would probably be the effect, on a mass of granite, for example, containing water intimately combined with its molecular particles, and confined beneath overlying rocks and seas, under circumstances of intense compression, and at the same time high and increasing temperature? Surely a tendency to intumescence, which, wherever, and in proportion to the extent to which it takes place, must elevate and fracture the overlying rocks, and likewise disintegrate more or less the crystalline particles of the swelling mass, through the irregularities of their internal movements and mutual friction. Many of the crevices broken through the neighboring rocks would be injected by the intumescent matter. Some may be sufficiently enlarged to allow of its forcing its way into the open air as a lava, perhaps accompanied by eructations of the gases and vapors developed in the lower parts of the mass, or, should the liquefaction not be sufficient to admit of the rise of aëriform bubbles, as matter of a porous, pasty, or glutinous consistency, perhaps even semisolid in texture and bulky in form.

It might happen that, circumstances occasioning in turn the preponderance of the compressing over the expansive forces (by reason, for example, of a diminution of temperature), portions of the subterranean crystalline mass will, after a partial intumescence of the kind supposed, return to a state of solidity. The result may be a more fine-grained rock, owing to the partial disintegration of the crystals; or, if the disintegration had proceeded sufficiently far, new mineral combinations might take place. Indeed, Watt long since proved that the particles of even apparently solid rocks are capable, through changes in temperature, of internal motion sufficient to admit their rearrangement according to polarity, that is, of crystallization. Still more likely is this result to occur on the condensation or escape of any fluid which had previously kept them from contact with each other, since the crystalline polarity can only exert itself within minute distances. And thus might we account for the frequently observed passages of granite and gneiss into syenite, greenstone, trap, or trachyte, and the varieties of mineral composition which

these rocks at times exemplify. So also the transitions from the larger crystalline grain to the finer, and the dykes and veins which these rocks so often contain themselves, or intrude into their neighbors. So too the finer grains of the sides, or selvages, of such dykes might be owing to the greater disintegration of the crystals by friction along these sides as the matter was driven through them.

Another problematical fact which this theory of an aqueous vehicle in heated granite would account for, is the usual appearance of the quartz in this rock, not in crystals, but as a paste or base, seeming to be moulded upon the crystals of feldspar. Had the rock crystallized from a state of fusion, the feldspar, being far more fusible than quartz, might have been expected to be the last, not the first, to crystallize. But if the water disseminated through the rock were supposed to have taken the quartz into solution by aid of the alkalies present in the feldspar, the fluid vehicle would in fact become a liquid or gelatinous silicate; and upon consolidation would naturally mould itself on the feldspar crystals, or appear as a paste to them. I adduced the hot siliceous springs of Iceland and other volcanic districts as proofs that heated water under such circumstances could dissolve silex.

Those who will take the trouble to refer to the 2nd, 4th, 5th, and 6th chapters of my "Considerations on Volcanos," will see that the above is a brief summary of the arguments there put forth, perhaps at too great length, and in a form which may have hindered their obtaining at the time of their publication the attention which I believe they merited.

Certain it is, that they were at that time, now thirty years back, neglected, or generally discredited. I was told that my views were "unchemical." I was represented as asserting incandescent lava to be "cold or thereabouts."* The igneous and the aqueous origin of certain rocks had been so hotly contested, and fire and water were usually considered so antagonistic, that it seemed at first view an absurdity to imagine that both could be combined in a substance seemingly in fusion. Probably also the idea was scouted at first through the notion that water could not be present within an incandescent mass of lava without causing it to explode like a mine; which might of course be the result of any considerable body of water being localized at one point. But the view I entertained, as has been explained, was that the water (and to some extent, perhaps, liquefied gases), to which I attributed much of the liquidity of some lavas, was disseminated throughout its mass, occupying minute interstices, and in intimate, though probably mechanical, combination with every molecule,—indeed intercalated between the plates even of its solid crystals; and moreover that the pressure to which the rock

* Westminister Review.

was subjected while beneath the earth was so enormous, as to prevent the vaporization of these minute portions of liquid anywhere except at points, where the intensity of temperature and consequently of expansive force overcame the resisting forces, and thereby caused either the formation and rise of great bubbles of vapor from the lower depths of the subterranean lava-mass, or the inflation of minor bubbles and pores throughout it, or at least in the superficial portions which by intumescence were forced into the open air.

Of late, however, views precisely in accordance with the theory printed by me in 1824 have been put forward, and have attained extensive adhesion among continental geologists.

M. Delesse has proved by experiment the solubility of the silex of rocks in heated water containing either of the mineral alkalies. And, indeed, the manufacture of artificial stone is now carried on in this country (Messrs. Ransom's process) by saturating loose sand with an artificial hydrate of silica. Huge blocks of flint, I understand, are thrown into the hot alkaline water, and melt down like so much sugar.

Again, the experiments of Boutigny have shown that water at a white heat remains unvaporized, in the form of spheroidal globules, in which form it is obvious how readily it would communicate mobilty to the solid particles among which it was entangled; and how (according to these experiments) it might flash into bubbles of vapor on the reduction of its temperature by exposure to the air.

M. Deville, in his recent observations on the vapors disengaged from Vesuvius since the eruption of May in last year (for the perusal of which I am indebted to the kindness of my friend Dr. Daubeny), arrived at the conclusion, to use his own words, that "water in the proportion occasionally of 999 per mille must have formed an integral part of the Vesuvian lava at the moment of its emission; and consequently, that in the interior of the incandescent lava there is such an arrangement of molecules, as to permit the gaseous and volatile matters to remain there imprisoned, until in the progress of cooling and consolidation, they evolve themselves."

Above all, M. Scheerer, of Christiana, the eminent Norwegian geologist, who is better acquainted perhaps than any other with the granites of that country, published in 1847 a theory, which, he says, his observations had suggested to him in 1833, on the production of granite, entirely identical with that which I had ventured to suggest in 1824–25. I take the following account of it from the paper read before the Geological Society of France in 1847, and published in the fourth volume of the Bulletin de la Soc. Géol., p. 468.

M. Scheerer attributes what he calls the "plasticity" of granite when protruded on or towards the surface of the earth (a condition evidenced by the veins it throws into the fissures of neighboring rocks) to the combined action of *water* and heat. He describes the water as "intercalated between the solid atoms of the crystalline and other constituent minerals, endeavoring to escape by its tendency to vaporization, and consequent elasticity, but unable to do so owing to the pressure to which the enclosing mass is subject." He considers the water so contained in granite to be "primitive," that is, one of the original bases of the rock, and not the result of infiltration. He attributes to it the solution of the quartz, aided by the alkali, and the consequent moulding of this mineral on the feldspar crystals. He even goes the length of styling the condition of granite before its protrusion by the term "une bouillie aqueuse," *a granitic broth*.

These theoretical opinions of M. Scheerer appear to have received the assent of M. Elie de Beaumont and other French geologists.* Their exact conformity with those which were first developed in my treatise on Volcanos, published in 1824–25, and repeated in the preface to my volume on Central France in 1826–27, will be evident to any one who will take the trouble to refer to those works.

It is not, however, for the vain purpose of claiming a priority in these views, that I now ask the attention of the Society to them, but because the subject has not, I think, yet attained the consideration I think it deserves from the geologists of this country; and especially because of its leading, if followed out, to further inferences of considerable importance, which were likewise suggested by me in 1825, but have been hitherto only partially pursued to their legitimate consequences.

*Laminated or schistose rocks, slaty cleavage, and folded rocks.*—I refer to the mechanical changes in the texture and structure of the plutonic rocks which could not fail to have resulted from the mutual friction of the component crystalline particles attendant on their internal movements, whether caused by mere dilatation and re-compression in place, or by a shifting of the entire mass in any direction, under intense and opposite, but irregular pressures.

I was led to reflect on this by observation of the ribboned pitchstones of Ponza and Ischia, in which, while in a state of vitreous fusion, crystallites had formed (just like those of the Oldbury obsidian), and subsequently been broken up by the movement of the semi-liquid mass, and drawn out into long stripes, giving a ribboned appearance to the rock.

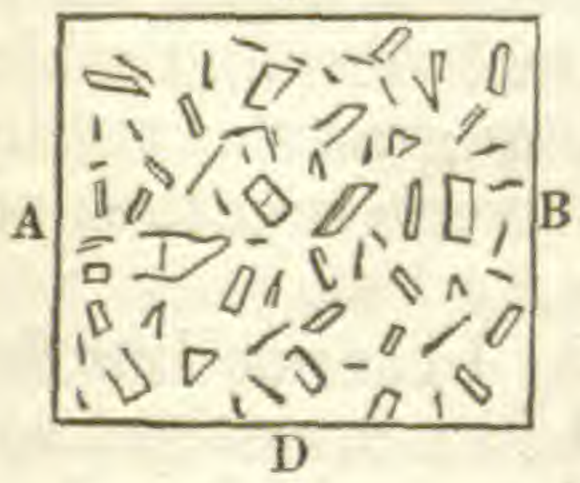
Further examination proved to me that the ribboned trachytes of Ponza and Ischia, and some ribboned clinkstones, owed that

* See *Bulletin de la Soc. Géol. France*, new series, vol. iv, p. 1312.

character to a similar elongation of the feldspar crystals and feldspathic particles which they previously contained, in the direction in which the semi-liquid mass flowed, or rather was forced to move, and in which the pores or cells, when there are any, are equally elongated. These observations suggested to my mind the reflection that the solid particles of any crystalline rock which is put in motion while in a state of imperfect solidity, and under the influence of opposing pressures, must be subject to a great amount of mutual friction or disturbance, by which their final arrangement when wholly consolidated will be determined.

Thus suppose a mass of granite, of which A B (fig. 4) repre-

4.




5.

sents the section, consisting of crystals of feldspar and mica irregularly disposed in a bases of more or less liquified or gelatinous silex, exposed to movement in the direction A B, while under vast pressure both from above and below, that is in the opposite directions C and D. Whether the surface, C, or D, or both, remained fixed, or merely moved, owing to resistances, at a slower rate than the other parts, the crystals in the latter would be turned round by internal friction, and rearranged and drawn out in stripes or planes in the direction of the motion, while the proportionate dimensions of the mass would be equally varied so as to produce a section something like E, F, G, H, (fig. 5), in fact, a rock which, if no further change occurred in it except consolidation in place, would have all the characteristics of *gneiss*. The same movement, if still further continued, might, it appeared to me, be expected to disintegrate the angular crystals of felspar altogether, so as to cause them to disappear, perhaps to force their elementary molecules to melt into the intensely heated silicate, to which they would impart their alkalies. And the resulting rock, supposing the laminæ of the mica-crystals to slide readily past each other, when lubricated by the silicate, and not therefore to be so far disintegrated as those of feldspar (as from their peculiar form might be expected), would put on a lamellar structure, and very much resemble *mica-schist*,—especially since the great flexibility of the mica would render its laminæ extremely liable to yield to the irregularities of pressure pervading the mass, in a variety of directions, and consequently to take

such wavings and contortions as are often exemplified in that rock. Whoever will examine the tortuous way in which the plates of mica envelope and bend round nodules of half-melted quartz or crystals of garnet in mica-schist, will be convinced, I think, that the whole mass has been subjected to great internal movement and consequent friction in the direction of the layers of mica, while under intense pressure, and in a comparatively softened state, the mica being lubricated, as it were, by a vehicle of liquid or gelatinous quartz. Whatever fissures or cracks were formed during this movement in the semi-solid rock, or subsequently, so long as the silicate remained unconsolidated, would be necessarily filled by it, and ultimately appear in the shape of the quartz-veins so frequent in this class of rocks.

Under this supposition gneiss and mica-schist would bear the same relation to granite as the ribboned trachytes and schistose lavas (clinkstone) to ordinary crystallized or granular trachyte; and the quartz rocks associated with granite, represent the quartzose trachytes of Hungary, Ponza, and the Andes.

These views, developed by me in 1825, I cannot but think, deserve the attention of geologists engaged in investigating the origin of the so-called "plutonic" and "metamorphic" rocks. It seems to me more probable that some process of this kind may have metamorphosed granite into the laminated rocks of plutonic origin, gneiss, and mica-schist, than that these rocks should have been formed by the mere fusion and reconsolidation or crystallization in place of sedimentary strata *already laminated*, according to the usual "metamorphic" doctrine. I can understand the clay-slates and other fine-grained schists to have been formed through the mechanical disintegration of mica-schist, but not mica-schist by the baking or melting and cooling of the clay-slates in place, in the manner suggested by Sir C. Lyell.

In the formation of the clay-slates, perhaps, the action of heat was not concerned (except as engendering the pressure to which they have evidently been subjected), but that of water or an aqueous silicate only. Still in their case also internal movements and mutual friction of the component particles under extreme and irregular opposing pressures have, I am convinced, had a primary influence in occasioning that parallel arrangement of the scaly and flaky micaceous particles to which their slaty cleavage is due. This, at least, was the conviction forced upon my mind by a close examination of the fissile clinkstone of the Mont Dor and Mezen, which is used for roofing-slate, and is in its lamination and cleavage undistinguishable from many clay-slates. And that opinion I recorded at the time in my 'Considerations on Volcanos.'*

* See pp. 103, 144, and 202.

I have since found this view of the origin of slaty cleavage supported by Mr. Darwin in his work on 'Volcanic Islands,' and by Mr. Sorby in his paper on slaty cleavage in the Edinburgh Philosophical Journal for 1853. I need not say that such support affords strong confirmation of its correctness.

Of course we are led to connect the movements under extreme pressure, to which this peculiar texture of the laminated rocks is here attributed, with the action of those same forces by which their beds have been so generally bent and contorted into a series of folds or wrinkles, more or less at right angles to the general strike.

If we seek to discover under what circumstances these flexures were brought about, we can hardly be wrong in ascribing them to the same violent process by which they have been elevated, usually on the flanks of some protruded ridge or enormous dyke of crystalline rock, which is seen to form the axis of the mountain range to which they belong.

Now what may we suppose to have been the character of this elevatory process?

The phenomena of active volcanos, and the protrusion of intumescent crystalline matter on so many points of the earth's surface, and at all periods of its history, may be admitted to prove the continued existence beneath a very large area of that surface—if not the whole—of a mass of intensely heated crystalline matter, having disseminated throughout its substance (in the manner already dwelt upon) some fluid or fluids, such as water, affording an imperfect liquidity to the mass, and by its intense elastic force, communicating to it a powerful tendency to expansion. Now suppose any considerable diminution to occur locally in the amount of pressure confining this expansible mass beneath the crust of the globe,—such as might be brought about by an extraordinary concurrence of the ordinary barometric, tidal, oceanic, or excavating causes, (not to suggest others),—or, on the other hand, any considerable increase of its expansive tendency, owing to a local increase of temperature, from some unknown, but easily imagined, cause,—we should anticipate, as the necessary result, the violent fracture and elevation of the overlying crust of rocks, and the extrusion through some principal fissure, or line of fracture, of a ridge of the subterranean intumescent crystalline matter.

It seems very probable that under such circumstances the central axis of the protruded ridge may retain its irregularly crystalline grain and structure, but that the portions of crystalline matter that from either side would rush or be thrust up by pressure from behind (consisting partly of the weight of the overlying rocks on the semi-liquid matter below them) towards the opening should be subjected to so much internal friction of their crystal-

line particles, and so much pressure at right angles, or nearly so, to the direction of the movement, as must stretch and draw them out into parallel planes,—just as happened evidently to the striped and ribboned trachytes in the protruded dykes of Ponza and Palmarola. This friction and pressure would be extreme, of course, along the lateral parts of the protruded mass, that is, the selvages of the great dyke; which, if the original mass were granite, would thus appear composed of an axis of granite, passing on either side into gneiss (or squeezed granite) and further on into mica-schist.

But every irregularity, whether on the large or the small scale, obstructing more or less the even motion of the layers, must create a waving or contortion in them, especially in the planes of slippery mica-plates, such as is exemplified even in hand-specimens of the Ponza trachytes, and also on the largest scale in the same locality. And the extreme irregularities of motion, occasioned on the upper layers of the intumescent mass by the pressure and resistance of the overlying beds, may be expected to carry their wavings still further, and at the throat of the fissure, where the squeeze and jam of the protruded matters must be at its maximum, to occasion those enormous and repeated zigzag foldings of the laminated beds, so frequently observed in mica and chlorite-schists in such positions.

Meantime another influence would be similarly affecting the overlying stratified rocks above, or on the outer flanks of the elevated axis, namely their own specific gravity, urging them to slide or slip laterally when tilted up at (perhaps) a considerable angle on either side. The more compact and indurated strata would be partly fractured into cliffy masses, partly broken up into breccias and conglomerates by this movement; but the softer beds, especially those which were saturated with water (perhaps even yet under the sea,) or which contained interstratified beds of silt, shale, or clay, permeated with water, would glide laterally away from the axis in extensive land-slips, and be wrinkled up into vast foldings under the intense pressure compounded of their own weight, and that perhaps of portions of the protruded matter thrust against them,—in a manner very similar to the contortions produced in the more crystalline laminated rocks by the violent squeeze which accompanied *their* protrusion. It may even be difficult to draw a line between the effects of these two replicating and fracturing forces. But, together, they seem to me sufficient to account for most of the phenomena of the kind observable in mountain chains.

These are the ideas on this subject which I endeavored to develope, though very imperfectly I am aware, in the more theoretic portion of my work on volcanos, so often referred to, and they were illustrated by a rude ideal section of an elevated

mountain chain in the frontispiece to the volume. I still think they will be found a not improbable solution of this the greatest problem in the dynamics of geology. It appears to me, that the results would be much the same, whether we suppose this elevatory action to have been *paroxysmal* and simultaneous, or gradual, taking place by minor and successive expansive throes or shocks, or even still more slowly in the manner of a *creep*, as Sir Charles Lyell would probably conceive it to have operated, and to be still continuing. On these last assumptions, the earthquake-shocks which certainly accompany at present every effort of elevation, and appear to be propagated in waves through the substance of the earth's crust, in directions usually at right angles to the principal axes of elevation, or fissures of crystalline protrusion, may indicate the force by which the extreme replications and slaty cleavage of the laminated beds are occasioned.

I would ask of geologists to consider whether such a mode of protrusion of the laminated crystalline rocks and of the lateral replication of the more earthy schists and marine strata, as is here suggested, does not accord with the general facts known respecting their position? Let me take two descriptions of the general position of the crystalline rocks from two writers of experience, judgment, and wholly impartial character, as respects the theory here indicated. Mr. Evan Hopkins* gives as the results of his extensive mining experiences in the Andes and elsewhere, "that the great base [of all mountain chains] is below more or less granitic, strongly saturated with mineral waters, and that this passes upwards by insensible gradations from a crystalline homogeneous compound into a laminated rock, such as gneiss, and still higher up into schists in vertical planes; the peculiar varieties of the higher rocks depending on the mineral character of the 'parent rock' below; the schistose rocks forming, in short, the external terminations of the great universal crystalline base,"—that is to say (as I would phrase it,) the squeezed out, and therefore laminated, upper and lateral portions of the inferior crystalline mass.

Mr. Ruskin, in his recently published volume, having closely examined the structure of the Alps with the eye of a geologist no less than of a painter, but certainly without any theory to support, declares that the central axes of "irregular crystallines" (as he calls the granitic rocks) uniformly graduate on either side into the foliated or "slaty crystallines," *i. e.*, into gneiss and ultimately mica and chlorite-schists.

One point observed in the structure of the Alps and many other mountain chains I may notice before I conclude, namely, the occasional dip of the elevated strata towards the central axis of extruded crystalline rock, producing a synclinal, instead of

* Quart. Journ. Geol. Soc., vol. xi, p. 144.

an anticlinal ridge. Another section copied loosely in the frontispiece to my work on volcanos, from Von Buch's paper on the Tyrol, may show the mode in which I conceive this to have occurred through the injection of a mass of crystalline matter into a wedge-shaped fissure, opening downwards; such as must have frequently occurred among the fractures of the overlying strata —giving occasion in some cases to the further rise of the heated and intumescent matter into the hollow between the outer slopes of the synclinal valley. It would indeed accord with the theory suggested above, if such dykes or extravasations at synclinal axes were found to alternate frequently with the elevated anticlinal axes, for the cracks formed in indurated beds of overlying rock would very frequently open alternately upwards and downwards.

Time will not allow of my dwelling now upon other points explanatory of geological problems, which are afforded by the theory of an expansive subterranean crystalline mass preserved by external pressure in a more or less solid condition beneath the crust of the globe, but always ready to expand and perhaps to intumesce upwards on any relaxation occurring in the overlying pressure. But I suggest it now, as I did thirty years since, as the solution most reconcilable with the known facts of the structure and relative position of the great elevated rock formations of the globe, and as a theory founded, not upon mere guess-work, but on careful and extended observation of the phenomena of both active and extinct volcanos, and the disposition of volcanic products of all ages.

---

ART. XVII.—*On the occurrence of Natro-boro-calcite with Glauber-Salt in the Gypsum of Nova Scotia;* by HENRY HAW, Professor of Chem. and Nat. Hist. King's Coll., Windsor, Nova Scotia.

THE Natro-boro-calcite, to which the following communication chiefly refers, must be ranked among the least common of minerals, inasmuch as it has hitherto been found in but one locality, and is not yet fully described in the manuals of mineralogy. The circumstances under which I have lately met with it will add not a little, I think, to the interest it already possesses, as it has been obtained in a new geological position, and in a state of greater purity than the specimens as yet examined seem to have had, so that I have been enabled to make out its true constitution which I believe, for reasons presently to be mentioned, has not till now been arrived at.

The brief history of the mineral is this. It was originally sent, a few years since, to Dr. Hayes of Boston, U. S., from Tara-

paca, in Peru, where it had been found in the nitrate of soda beds. From the analysis of this chemist it seemed to be composed of water, lime, and boracic acid, and he called it hydro-boro-calcite. Ulex, however, examined a specimen from the same locality, and finding it mixed with the nitrate and sulphate of soda, he boiled the whole with water for the extraction of these, and, analyzing the residue, he expressed his results in this formula,

$$NaO\,2BO_3 + 2CaO\,3BO_3 + 10HO,$$

and he named the mineral Natro-boro-calcite. Professor Anderson, of Glasgow, afterwards analyzed a specimen from the same locality, which, though somewhat mixed with foreign matter, he shewed to consist essentially of the mineral of Ulex. A few observations extracted from the paper containing these results,* will sufficiently mark the characters of the Peruvian mineral, and what is known of the geological nature of its till now unique locality.

"The Natro-boro-calcite is found in the nitrate of soda beds of the province of Tarapaca, in Peru, and is known to the natives by the name of Tiza. It occurs in rounded masses, varying from the size of a hazel-nut to that of an egg. Externally these have a dull and dirty appearance; but when broken across they are found to be formed of a series of interlaced needles of a brilliant white color, and silky lustre. These crystals were extremely minute in all the pieces I examined, but the specimen analyzed by Hayes was composed of prisms a quarter of an inch in length.

"The qualitative analysis indicated the presence of boracic and sulphuric acids, lime, soda, water, siliceous sand, and traces of chlorine. Ulex found also traces of nitric acid, but that which I examined contained none.

"The quantitative analysis gave results according very closely with those of Ulex, excepting that previous to his analysis he boiled the mineral with water, to extract the nitrate and sulphate of soda which he had detected, and which are obviously a mechanical admixture. This was not done in my case, as the analysis was made for commercial purposes and I was desirous of ascertaining its exact composition as it occurs. Ulex obtained:

| | Expt. | Calc. |
|---|---|---|
| Water, | 26·0 | 25·60 |
| Lime, | 15·7 | 15·93 |
| Soda, | 8·8 | 8·82 |
| Boracic acid, | 49·5 | 49·64 |
| | 100·0 | 100·00 |

which numbers agree very well with the formula,

$$NaO\,2BO_3 + 2CaO\,3BO_3 + 10HO.$$

* Proc. Phil. Soc. Glasgow, Feb. 1853.

The conditions under which this substance is found in loose masses in the nitrate of soda beds, give it a peculiar interest in a scientific point of view, and render it highly desirable that we should have full details of all the circumstances of its occurrence. The district of Tarapaca has been as yet but little explored, but it would appear that it is chiefly volcanic, and it is remarkable that up to the present moment boracic acid has never been found abundantly except in volcanic districts."

The rock in which I met with the mineral, in March last, is part of a very extensive formation of gypsum in the western centre of Nova Scotia, and the precise locality a bed of it at Windsor, on the Clifton estate, lately the property of Judge Haliburton. My attention was first drawn to the other mineral I have named at the head of this paper, the glauber-salt, as a curious 'stuff' which had attracted the notice of the quarrymen, and which they called "salts." Upon the specimens of "salts" shewn to me I at once saw that at least two distinct minerals were present, and procuring sufficient of both from the spot myself, I submitted them to examination. I give the chemical analysis in the first place, and afterwards the description of the minerals and locality.

The glauber-salt was easily separated in a pure condition, and its analysis in the fresh state gave,

| | |
|---|---|
| Sulphate of soda, - - - - | 44·54 |
| Water, - - - - - - | 55·46 |
| | 100·00 |

showing that it was the ordinary mineral,

$$NaO\,SO_3 + 10HO.$$

The second substance reminded me of the Tiza which I had seen in the hands of Dr. Anderson, in Glasgow, and a careful selection of pieces being made, it was proved by the following results to be identical with that curious mineral. The water was found by gentle ignition, the soda estimated as sulphate in a portion of the dry residue from which the boracic acid was expelled as fluorid of boron, the other ingredients in a separate quantity, the boracic acid by deficiency. The whole results were calculated upon the *air-dry* mineral, which was always employed for analysis, and I obtained from the substance as it occurred:

| | |
|---|---|
| Soda, - - - - - - | 8·36 |
| Lime, - - - - - - | 13·95 |
| Boracic acid, - - - - - | 41·97 |
| Water, - - - - - - | 34·39 |
| Sulphuric acid, - - - - | 1·29 |
| Magnesia, - - - - - - | 0·04 |
| | 100·00 |

numbers which, notwithstanding the high percentage of water, showed me that I really had to do with natro-boro-calcite. Considering the two ingredients last mentioned as accidental, I treated a portion of selected mineral with *cold water*, washed well with the same, allowed the residue to dry in the air, and analyzed it. It was perfectly free of sulphuric acid, and gave of the other constituents,

| | Experiment. | Calculation. |
|---|---|---|
| Soda, - - | 7·21 | 7·82 |
| Lime, - - - | 14·20 | 14·12 |
| Boracic acid, - | 44·10 | 44·02 |
| Water, - - | 34·49 | 34·04 |
| | 100·00 | 100·00 |

The recurrence of the high percentage of water and the accordance of my experimental numbers, both from the purified and the actual mineral, with the calculated figures, are ample warrant, I think, for the following formula which I propose as the true expression for the air-dried natro-boro-calcite, viz:

$$NaO\,2BO_3 + 2CaO,\,3BO_3 + 15HO,$$

which differs from that of Ulex, before given, by five additional atoms of water; these, I think it extremely probable, were removed by the manipulation with boiling, and possibly by desiccation at 212°. Indeed I found that when the air-dry mineral was placed in the air-bath at this temperature, it lost, upon separate occasions,

| | I. | II. | Mean. |
|---|---|---|---|
| Water = | 8·25 | 7·58 | 7·91 per cent. |

which deducted from my total loss, above, leaves 26·49 for the amount retained, a number so close to that really obtained by Ulex—26—as to leave me little doubt that mine is the true expression. I find also that Hayes* originally gave thirty-five per cent water as the result of his analysis.

The minerals just described were found in the closest association in narrow cavities, perhaps two inches deep, forming a kind of interrupted vein in the body of the solid gypsum-rock, exposed by blasting, about thirty feet below the surface, and extending horizontally some few feet. The more abundant mineral of the two was the glauber-salt, so far as I observed personally, but the quarry-men told me that at first the other came out in "bowlfuls," but they threw it away. I did not obtain more than a few ounces of the natro-boro-calcite, and perhaps not a pound in all was preserved by those who obtained it on this occasion.

* Liebig und Kopp's Jahresbericht, 1849, p. 780.

The glauber-salt was perfectly transparent on the first exposure, and afforded a remarkably fine instance of the crystalline forms of the mineral, some crystals which I saw partially effloresced were at least $1\frac{1}{2}$ inch in length. Many masses were penetrated by perfect crystals of selenite, of various sizes, simple and in macles.

The natro-boro-calcite was along with and among the crystals of the preceding glauber-salt, and in some instances the latter seemed to be crystallized upon the former as a nucleus, or possibly they were in definite combinations as a totally distinct mineral; for crystals which at first were beautifully transparent would effloresce after a day's exposure or less, and upon being placed in water shew the silky texture peculiar to the Tiza, while plenty of sulphate of soda was to be found in the water. In other specimens, the natro-boro-calcite was alone in rounded mammillated masses in the substance of the gypsum; and these, which were of all sizes up to that of a pigeon's egg or so, on being broken, presented the appearance of a finely fibrous silky-lustrous mass brilliantly white in color.

The purest pieces had a specific gravity of 1·65; hardness =1; were tough between the teeth; tasteless; scarcely soluble in water; before the blowpipe, melted with ease to a transparent bead.

On comparing the circumstances of this occurrence with those referred to in the remarks of Professor Anderson, before quoted, and some other facts I think they are very interesting. In the gypsum of Nova Scotia we have a new and distinct locality for the rare mineral natro-boro-calcite which is analogous with that of a species chemically allied,* boracite ($MgO\ BO_3$), found in the gypsum of Holstein, and a compact boracite forming beds with rock-salt and gypsum at Stassfurth in northern Germany.

With these exceptions, boracic acid is found, as is well known, either in directly volcanic regions, most abundantly as such or as borax, and a well marked case of actual sublimation of the acid, from a volcano in the Island of Vulcano near Sicily has been studied by Warrington;† or in smaller amount in minerals the products of recent or extinct volcanoes, as Humboldtite,‡ from ejected blocks of Vesuvius and zeolites, and Datholite from trap of Salisbury Craigs, New Jersey, and other places; or in minerals of purely plutonic or metamorphic rocks, as tourmaline, the rhodizite of Rose, and axinite; the species which contain it at all being few in number. It may be noticed also that traces of this acid have lately been met with in the Kochbrunnen of Wiesbaden,§ and in the waters of Aachen.

* Nicol's Mineralogy, p. 305.
‡ Nicol's Mineralogy, p. 307.
† Wells' Annual, 1856, p. 232.
§ Liebig und Kopp's Jahresbericht, 1852, p. 328.

If we may reason from the character of the majority of its situations, we may almost consider the volcanic or at least igneous origin of boracic acid so well established as to lead us by its occurrence in the saliferous strata to seek for some volcanic agency as the cause of their production.

Such an origin has already been assigned, I find, to the gypsum of Nova Scotia by Mr. Dawson.* This formation has been shown to be a member of the Lower Carboniferous series, and is assumed to have arisen from the action of rivers of sulphuric acid more or less dilute, such as are known to exist† in various parts of the world, issuing from then active volcanoes, and flowing over the calcareous reefs and bed of the sea. "In accordance with this view the gypsum is found only in association with the marine limestone, though, as might have been anticipated, these last sometimes occur without any gypsum.‡

Gypsum, which is geologically of very various ages in different countries, was supposed by the writer just quoted, to be peculiar to the Lower Carboniferous series in Nova Scotia alone, but it has been shown by Prof. W. B. Rogers§ that a bed of this substance with rock-salt occurs in a thick deposit in limestone of the same period near New River in Virginia.

I think the occurrence of natro-boro-calcite in the gypsum of Nova Scotia cannot but lend support to the theory of Dawson as to the origin of this rock, when all the circumstances above mentioned are considered; and that a search for it or some equivalent in similar situations, might lead to more conclusive evidence as to the geological causes of the Saliferous systems in general, and furnish additional links of union between the sciences of geology and mineralogy.

---

## Art. XVIII.—*Arctic Explorations, by Dr. Elisha K. Kane, U.S.N.*‖

The writings and explorations of Dr. Kane are so widely known, and the volumes are so accessible to all, that a review of his works in this Journal seems hardly necessary. There are however scientific observations scattered through the volumes which it may be convenient to have here indicated if not placed in detail on record, and some results of his investigations which are profitable subjects of discussion and of wide import in science.

* Acadian Geology, p. 223.
† Lyell's Elements, Chap. xvi.
‡ Acadian Geology, p. 224.
§ Edin. New Phil. Journ., Ap. 1857, p. 360.

‖ Arctic Explorations: The First United tates Grinnell Expedition in Search of Sir John Franklin. A personal narrative, by Elisha Kent Kane, M D, U. S. N. 1 vol. 8vo. Philadelphia: 1857. Childs & Petersen.—The Second Grinnell Expedition, ibid., 2 vols. 8vo. 1857. Childs & Petersen.

The volume on the First Expedition is a new edition, with many additional illustrations.

Moreover we would add our inscription to the monument over the distinguished traveller. There are those who deplore so great exposure of life for the empty pursuit of geographical or scientific discovery amid the polar ice, deeming the establishment of a mere truth in science as small game compared with catching great whales and valuable seals.* It is to the credit of the race, that all are not thus narrowed down to earth and commerce. There are those that love knowledge for its own sake, and in such, mind declares its supremacy over the material, and exhibits its true exaltation. While we estimate moral triumphs above all others, we would give high honors to self-sacrifice for any great intellectual purpose, and to none more than to that of the daring navigator through polar seas. In this class Dr. Kane stands preëminent. The beneficent object also in view,—the discovery of the ill-fated ships of Sir John Franklin,—adds a still higher lustre to his name, which is shared alike by his generous patron, Henry Grinnell.

The public are greatly indebted to the enlarged views of the publishers of Dr. Kane's works, who have given them every attraction to be derived from excellent paper and typography, and a profusion of fine engravings.

In our citations from the work we shall be brief, leaving it for the reader to gather the detailed descriptions from the graphic pen of Dr. Kane himself. Moreover we shall touch only on a few of the points illustrated in the volumes, selecting especially those which have some geological bearing, and using them partly for the illustration of some topics under discussion among geologists.

Although the works may be in the hands of most of our readers, it is still desirable to give here, by way of introduction, the courses of the two cruises. The first expedition, consisting of the two vessels, Advance and Rescue, was under the command of Lieut. Edwin J. DeHaven, U. S. N., with whom Dr. Kane went out as surgeon. It sailed from New York on the 22d of May, 1850. Passing up Davis Straits and Baffin's Bay, the vessels coasted along Greenland, stopping at Disco, and continued through Melville Bay to its north cape; then crossed Baffin's Bay to Barrow Straits, and onward to Wellington Channel, near the entrance to which, the graves of some of Captain Franklin's men were found. From this place the winter drift of the vessels began; it was first to the north, up Wellington Channel to lat. 75° 25′, and lon. 93° 31′, then south (commencing Oct. 2, 1850) down this channel, and east through Barrow Straits into Baffin's Bay, to lat. 66°, lon. 58°, July 8, 1851, where they escaped from the

* Dr. Kane observes that in one year more than a thousand human beings in fishing expeditions were cast shelterless on the ice in Melville Bay, Greenland. A hecatomb has been sacrificed to trade for every Arctic explorer that has fallen.

ice which had enclosed them. The vessels after revisiting the Greenland coast, reached New York in September.

The second expedition, under Dr. Kane, left New York on the 30th of May, 1853, reached Fiskernaes, Greenland, on the 1st of July, passed up the west side of Greenland across Melville Bay, and so on north through Smith's Straits some forty miles wide at the head of this bay, into Kane's Sea its continuation sixty to eighty miles in width; and near the entrance of this sea on the Greenland side, in lat. 78° 37′, lon. 70° 40′, at Rensselaer harbor as they named it, the vessels came to winter quarters, in the latter part of August, 1853. Here they remained through the winter and a following summer and winter, making occasional excursions on foot or with sledges to the east, west, and far north. The recital of their arctic life is a tale of constant adventure and suffering, but also of successful defiance of nature's fiercest rigors; and this display of man's nobility gives a charm to the pages that are otherwise an array of dismal scenes in long gloomy succession. On May 20, 1855, the party left the vessel, and made its hazardous way over the ice and by water to the Danish settlement of Upernavik, in lat. 72° 40′, where they arrived after a journey of extraordinary perils, early in August. A Danish vessel, in September, took them to Godhavn, where they joined Capt. Hartstene, U. S. N., who had been sent to their rescue.

1. *Oceanic Currents.*—The oceanic currents, as illustrated by the Arctic cruisers, are well exhibited in a map prepared by C. A. Schott, Esq., of the U. S. Coast Survey, published with the journal of the first expedition. The grand point brought out is the general oceanic movement by all accessible channels southward from the polar sea. It is like the discharge of an over-full polar basin, sending its majestic outflows by every place of exit that offers. The waters pass down through Barrow Straits from the channels about Melville Island and from Wellington Channel, and pour themselves into Baffin's Bay, and thence down Davis Straits to the Atlantic. Another stream goes by Hudson's Straits to join the former in its southerly course, and the two unite with the great flow of cold water that comes down by eastern Greenland. These currents are not made known for the first time by the American expeditions, but their results have added to the definiteness of our knowledge on the subject. The remarkable drift of the vessels, in the first cruise, for 1000 miles, from Wellington Channel to lat. 66° and lon. 58° in Baffin's Bay, is the most remarkable current experiment that any of the world's explorers has made, and it is none the less important, that it was unplanned and involuntary.

In addition to the flows mentioned, there is also a stream descending from the far north by Baffin's Bay, through Smith's

Straits or Kane's Sea (the scene of the adventures of the second cruise), which joins that from Barrow Straits, thus making in all a descending polar flow bv Eastern Greenland, Western Greenland or Smith's Straits, Wellington Channel, and one or more channels about Melville Island, besides that into the Pacific Ocean by Behring's Straits. The Behring's Straits current, though not always noticed at the surface, shows itself in the cold waters that flow by the China coast far towards the equator, making deep bends in the winter isothermal lines, and even pushing south of its normal limit the heat equator of the ocean.* It is well known that a current descending from the poles necessarily hugs the eastern coasts of lands or takes the west side of the ocean, it thus lagging westward because the motion of rotation at the poles is at a less rate than farther south. It is also understood that a flowing current will, by its own movement, draw in waters from its sides, and especially, when, as it descends a channel, the channel widens rather suddenly into a bay, and hence while the great flow in Baffin's Bay passes south along its western side, there is a counter current flowing north on the eastern side. Dr. Kane speaks of this current to the northward as made by the east Greenland current bending around south Greenland and changing to a northerly course. We should rather view it in the manner suggested, as a movement produced by the great northern current, and fed by whatever waters lie along western and southern Greenland, including of course part of those descending in the east Greenland current. In the great expedition-drift the vessels made 170 miles in the month of December, and 190 in that of May.

Writers on physical geography, as Dove and others, correctly attribute the supply of the polar seas with its superabundant waters, to the great Atlantic flow or Gulf Stream. The ocean pours north through the opening between Great Britain and Iceland, and streams out again by the various outlets which lie open before it.

The magnitude of these movements show that they belong to the organization of the earth, and as much to its geological past as its present history. They are therefore correctly appealed to by geologists in discussions of the origin of all marine strata; and especially the ancient, which are more exclusively marine. The Azoic back-bone of the continent lying just east of the line of lakes including Winnipeg and Slave lakes, and bending northeast in Canada, so as to include Hudson's Bay in its two arms,† must have always had its northern currents hugging its eastern side; and whenever the Rocky Mountains rose as a barrier

* See an isothermal chart by Prof Dana in this Journal, vol. xvi, p. 153.
† See this Journal, vol. xxii, p. 335.

against the waves, this emerged ridge would be bordered by another part of the polar current; and so also for the lower Appalachian ridge: while farther south, the warmer equatorial currents would sweep on, moving over and partly to the eastward of these colder streams, especially after passing north of 35° or 40°. The effects of the distribution of material by the agencies of these marine movements on the origin of the older formations, remain to be studied out. Their importance has been admitted but not fully appreciated.

In discussions of the phenomena of the so-called Drift-period, oceanic currents are constantly referred to by those who attribute the effect to glaciers; and the example of the glaciers that float down to the Newfoundland Banks are the usual appeal.

But instruction from the north tells us, that the Newfoundland icebergs have brought their stones one or two thousand miles, and often by a very circuitous route, while those of the drift in America have traveled only twenty to two hundred miles, so that to find a parallel we must look to the shorter transfers and droppings in the far north itself, where abundant lands exist for making glaciers and icebergs. Again, the currents change with the course of the land; they are east and west in Barrow Straits, and north-northwest and south-southeast in Baffin's Bay; and moreover they have their powerful counter-currents. Consequently the position of the emerged land or coast-line of the drift period would have *then* given the course to the currents and glaciers; if this coast line were east-and-west, along by Pennsylvania and the Ohio, to the territories west of the Mississippi (the southern limit of the drift), the currents would have been nearly east-and-west, and no chance would have existed for making the north-and-south or northwest-and-southeast scratches, which are so uniform and widely distributed over the continent within the drift limits. Moreover the very uniformity of direction in the scratches and lines of stones, comes out against counter-currents, and against the fact of any bergs drifting outside of the northerly current, where they might be floated by other currents or carried irregularly by the winds, that is, they militate against the very occurrences that must have happened if the ocean had been the active agent in the drift period.

The example among Arctic currents of diversity of direction, and the still greater diversity in the courses of bergs, give the geologist little authority for concluding that in the drift period they could have been made to scratch with a nearly common course (between NW and NE) for a breadth of one or two thousand miles.

*Icebergs, Glaciers.*—The work of Dr. Kane abounds in views of icebergs, vivid descriptions of iceberg scenery, and accounts

of the varieties of ice and its changing conditions. He speaks of the great pack which occupies the middle area of Baffin's Bay, as if lying in the eddy between the polar current on the west side and counter current on the east; of many bergs in the bay 200 feet and upwards in height, of some "over 300 feet," an unusual altitude even in those iceberg regions; of 280 glaciers of the first magnitude within sight at one time;* of Jacob's Bight, a fiord on the Greenland coast near lat. 71° and lon. 56°, as "perhaps the most remarkable place for the genesis of icebergs on the face of the globe;"† of the immense "Humboldt glacier," in Western Greenland, which ranges on the coast from Cape Agassiz in lat. 79° 20′, to Cape Forbes beyond 80°, a distance of forty-five miles; of all northern Greenland as one continental glacier, having its many outlets along the fiords and valleys of the coast.

As to the kinds of ice-fields apart from the bergs: he describes (1) the more solid winter floe, seven feet to as many inches thick, which contains no trace of salt at surface (as shown by testing with nitrate of silver) when but two feet thick; (2) the water-sodden ice, which although supporting a person walking over it, breaks readily when struck, and displays "the vertical prisms of its crystalline structure;" (3) a honey-comb or cellular kind, "so soft that you may plunge a boat-hook into it;" (4) a granulated variety, which while "thoroughly permeated by water, is as unyielding as asphalt," and which could be punctured with a boat-hook, but would not fracture more than cork. Over the surface of the pack usually rests a mantle of snow, and here and there are pools of water, the haunts of the seal and the diver. The movements of the pack bringing parts against one another, often force up hummocks of huge uplifted masses one lying upon another, and these hummocks are at times clustered in great numbers over an ice field. Not unfrequently the great slabs of ice thus thrown up, and supported only at one end, gradually become flexed by their own weight, showing a yielding or molecular movement even in the solid glassy ice. Dr. Kane observes, "On the 20th of March, while we were imbedded in the floe with a temperature many degrees below zero, one of those great convulsions called *hummocking* had thrown up a table eight feet in thickness by twenty or more in width, and in such a position that it was sustained only at its two extremi-

* "Night before last, standing on the fast floe, I counted, between the two anchored bergs that served as framings of the picture, thirty-two icebergs in a well-marshaled group. Standing afterward on the summit of our northern buttress, I counted two hundred and eighty, the glacier terminating the eastern view. Most of these bergs were above the standard height of two hundred and fifty feet; some exceeded three hundred; few were less than one hundred."—*First Cruise*, p. 467.

† First cruise, p. 55.

ties. In the month of May, the thermometer, in the mean time, never having risen in the interval to within many degrees of the freezing point, I saw the same ice-table completely bent down, its centre depressed five feet, until arrested in its descent by a new support." These facts are referred to as proving a yielding nature in ice, even when solid instead of *half*-compacted. The bergs are described as *not* of the nature of the nevé or consolidated snow, as Prof. Forbes suggests, but as *true ice*, "having the fracture lustre, and other external characters of a nearly homogeneous growth, although they may be opaque and vesicular." He remarks that the berg is the foot of the glacier that quietly detaches itself while it lies stretching itself out in the sea, and not an avalanche that has fallen from the land.

On the disappearance of the ice-fields, we cite the following statements as bearing on the question of the disappearance of ice in Lake Champlain:—

"It was interesting to observe the compensations by which Nature got rid of this vast accumulation. The simple effects of solar heat, whether from the atmosphere above or the heated currents below, do not satisfactorily explain the dissolution of this ice. Changes in its mechanical structure evidently took place, preparing the way for the subsequent actions of thaw. My attention was first called to this fact by hearing, through my friend, Lieutenant Brown, that the observatory of Sir James Ross at Leopold Island was moist and saggy, while the outside ice remained dry and firm. In the month of May, while our mean temperature was still below the freezing point, I noticed, during my walks over the ice, that certain surface floes, which had been during the winter hard and fresh, began to yield under me as I walked, and gave a decidedly brackish taste to the palate. The ice, too, in many cases lost its tenacity and resistance. Our coal, which had been thrown out loosely on it, so depressed the little area around it, as to be surrounded by water; and some of the larger hummocks, whose colossal blocks had attracted my attention during the winter, were now wet and marshy to approach. Upon excavating blocks of ice with the saw and pickaxe, it was found, in many cases, to have lost its well-condensed character. It was divided by vertical lines into prisms, which stood prominently out, and ran continuously from the watery to the atmospheric surface, with an arrangement almost basaltic.*

"Struck by this circumstance, I was led to test the ice of different localities by both the Marcet's bottle and the nitrate of silver, and discovered that the floes, which had formed in midwinter at temperatures below −30, were still fresh and pure, while the floes of slower growth, or of the early and late portions of the season, were distinctly saline. Indeed, ice which only two months before I had eaten with pleasure, was now so salt that the very snow which covered it was no longer drinkable.

* "I am happy to find since my return, that this basaltic arrangement of the ice has been noticed by Sir John Richardson."

"This is a subject well worthy of future examination. The dissolution of the great ice-fields of the Polar regions bears upon physical questions of the highest importance; and it really seems to me that changes, independent of expansion and contraction, must take place in the molecular condition of the ice at temperatures greatly below the freezing point."—*First Cruise*, pp. 391–392.

Dr. Kane also alludes to an action like endosmosis from the pools of fresh water above and salt water below, as probably having some effect. But if so, it would be confined to the salt seas. The basaltic character of the ice, and its becoming permeated with water and breaking up into prisms, has been noticed on Lake Champlain by Dr. Hatch of Burlington, Vermont. The swell of the ocean is an important agent in the final destruction of the floe in the polar regions, and a storm gives it great power.

In the gradual wasting of some bergs, they became covered with circular depressions a foot in diameter; and one tall and slender one was so strikingly spotted in this way that Dr. Kane gave it the name of the Giraffe. No sufficient reason for the peculiarity is mentioned.

We cite a few sentences on the rolling over of a berg and some of their movements:—

"Nothing can be more imposing than the rotation of a berg. I have often watched one, rocking its earth-stained sides in steadily-deepening curves, as if to gather energy for some desperate gymnastic feat; and then turning itself slowly over in a monster somerset, and vibrating as its head rose into the new element, like a leviathan shaking the water from its crest. It was impossible not to have suggestions thrust upon me of their agency in modifying the geological disposition of the earth's surface."—p. 455.

"The berg is beyond all doubt a most important agent in modifying the soundings upon the coast. The grounded bergs off Disco are known to leave troughs, plowed by their projecting tongues, as they float and ground with the rise and fall of the tides. Where the bottom is of mud and till, as is the case on the west coast generally, this action must be very marked; for on a berg I surveyed trigonometrically in July, which had grounded in soundings of five hundred and twenty feet, the great tap-root that anchored it to the bottom admitted of an easy rotation, and the berg swung upon its axis with each change of the tide.—p. 458.

*Arctic turf.*—The following description of the turf found in Arctic regions has interest to the geologist, and we therefore cite it, although published in the earlier work of Dr. Kane. Speaking of a small cove near lat. 76°, the author thus writes:—

"Strange as it seemed, on the immediate level of snow and ice, the constant infiltrations, aided by solar reverberation, had made an Arctic garden-spot. The surface of the moss, owing, probably, to the extreme alternations of heat and cold, was divided into regular hexagons and other polyhedral figures, and scattered over these, nestling between the

tufts, and forming little groups on their southern faces, was a quiet, unobtrusive community of Alpine flowering plants. The weakness of individual growth allowed no ambitious species to overpower its neighbor, so that many families were crowded together in a rich flower-bed. In a little space that I could cover with my peajacket, the veined leaves of the Pyrola were peeping out among chickweeds and saxifrages, the sorrel and Ranunculus. I even found a poor gentian, stunted and reduced, but still, like every thing around it, in all the perfection of miniature proportions.

"As this mossy parterre approached the rocky walls that hemmed it in, tussocks of sedges and coarse grass began to show themselves, mixed with heaths and birches; and still further on, at the margin of the horseshoe, and fringing its union with the stupendous piles of debris, came an annulus of Arctic shrubs and trees.

"Shrubs aad trees! the words recall a smile, for they only typed those natives of another zone. The poor things had lost their uprightness, and learned to escape the elements by trailing along the rocks. Few rose above my shoes, and none above my ankles; yet shady alleys and heaven-pointing avenues could not be more impressive examples of creative adaptation. Here I saw the bleaberry (*Vaccinium uliginosum*) in flower and in fruit—I could cover it with a wine-glass; the wild honey-suckle (*Azalea procumbens*) of our Pennsylvania woods—I could stick the entire plant in my button-hole; the *Andromeda tetragona*, like a green marabou feather.

"Strangest among these transformations came the willows. One, the *Salix herbacea*, hardly larger than a trefoil clover; another, the *S. glauca*, [S. Uva-ursi], like a young althea, just bursting from its seed. A third, the *S. lanata* [S. arctica], a triton among these boreal minnows, looked like an unfortunate garter-snake, bound here and there by claw-like radicles, which, unable to penetrate the inhospitable soil, had spread themselves out upon the surface—traps for the broken lichens and fostering moss which formed its scanty mould.

"I had several opportunities, while taking sextant elevations of the headlands, to measure the moss beds of this cove, both by sections where streams from the lake had left denuded faces, and by piercing through them with a pointed staff. These mosses formed an investing mould, built up layer upon layer, until it had attained a mean depth of five feet. At one place, near the sea line, it was seven feet; and even here the slow processes of Arctic decomposition had not entirely destroyed the delicate radicles and stems. The fronds of the pioneering lichens were still recognizable, entangled among the rest.

"Yet these little layers represented in their diminutive stratification, the deposits of vegetable periods. I counted sixty-eight in the greatest section.* Those chemical processes by which nature converts our autumnal leaves into pabulum for future growths work slowly here."—*First Cruise*, pp. 142, 143, 144.

* "I copy the number of these layers as I find it marked in my journal; yet I do so, not without some fear that I may be misled by the chirography of a very hurried note. My recollections are of a very large number, yet not so large as that which my respect for the *littera scripta* induces me to retain in the text."

*The Polar Sea.*—The "open polar sea" is the grand discovery announced by Dr. Kane that has excited most attention. What was a mere matter of speculation has passed into the sober narration of a cautious and credible Arctic voyager. Yet all naturally receive the conclusion with a grain or more of doubt. It is against old notions; and moreover it is urged with reason, that the sea was not seen by Dr. Kane himself but by two of his men; that the whole extent of clear water claimed is but sixty miles square (4000 miles), and that the mirage of those northern regions, which in Dr. Kane's experience played such pranks again and again with the mountains and ice, and exaggerated or diminished distances beyond the power of reason to correct or allow for, might have led to an over-estimate of the extent of open water discovered.

The excursion to the north, from the vessel at Rensselaer Bay, was undertaken in June of 1854, after they had already been ten months ice-bound. The party consisted of two men by the names of Morton and Hans, the latter an Esquimaux, Dr. Kane at the time being too much disabled to join them. Fifteen or twenty miles north of the parallel of 80°, the water called Kane's Sea narrows to forty or fifty miles, and here it has been named Kennedy's Channel. Near the entrance to this channel, about two degrees north of the vessel, they found open water, the temperature of which was 36° F., with no solid ice beyond.* Morton continued up Kennedy Straits with his companion, and finally reached the parallel of 81° 20′, on the Greenland side, where he was stopped by a bold cape. Here, from a height of 480 feet, commanding a horizon of "almost forty miles," "his ears were gladdened with the novel music of dashing waves, and a surf breaking in among the rocks at his feet." About the ship no birds of the returning season had been seen. But here on the borders of the open sea, "the Brent goose (*Anas bernicla*), the eider and the king duck, were so crowded together that our Esquimaux killed two at a shot with a single rifle-ball. The Brent goose had not been seen before since entering Smith's Straits." The rocks were crowded too with swallows. There were also four species of gulls; and at the farthest point, Morton saw the Arctic petrel (*Procellaria glacialis*) "flitting and hovering over the crests of the waves," a bird which was last seen, when the vessel was on its way north the preceding season, 200 miles south of where they then were; and as it feeds on the life of the waters, it is one that requires an open sea.

* Dr. Kane states, that in latitude 78° 50′, near Rensselaer harbor, when the temperature at the surface of the ice-floes was −30° F., it was −8° at a depth of two feet in the ice, +2° at four feet, and +26° at eight feet. The freezing point of sea-water at Rensselaer harbor was 31° F.

The coast of Greenland at the point reached (named Cape Constitution) appeared to trend off to the eastward, while on the opposite side, the shore of Grinnell land stretched on to the east of north as far as the eye could reach, the farthest point seen being put down in lat. 82° 30′, and long. 66°. This point is within 450 miles of the pole. The mountain heights on this (the western) side varied from 1500 to 2500 feet, while farther south, opposite Rensselaer harbor, they were 1200 to 2000 feet.

Such is the account and such the nature of the evidence which the distinguished navigator has furnished respecting the open polar sea. Taking the facts as narrated, supposing no error from refraction or otherwise, it is reasonable to infer from the existence of so large a body of clear water its connection with a much larger one, since the circumstances of intense cold that would cover the waters around with ice, would not leave a spot of so limited extent uncovered except as a temporary condition; and the birds and abundant life sustain the conclusion that it was no unnatural event, for, in their migrations with the seasons, they are always regarded as good thermometric indicators. But admitting that the open sea exists, the trend of the Grinnell land to the east of north, leaves it uncertain in what latitude —whether on the American side of the position of the pole, or the opposite, or both,—the waters stretch off westward, which make up the so-called Polar Sea. The *open* sea may lie wholly on the Atlantic side of the pole, as far as the account fixes its position.

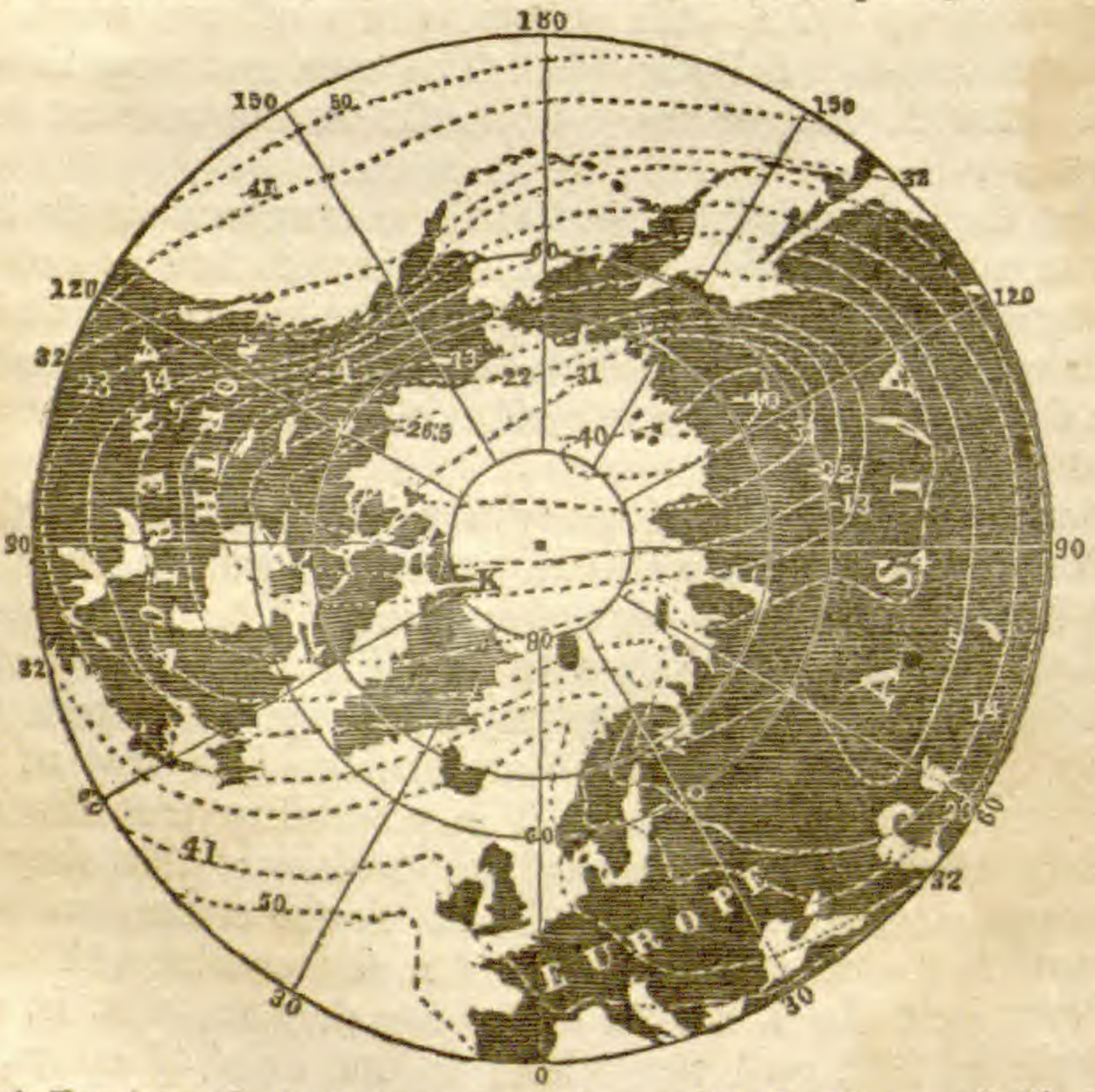
Under the doubts which necessarily rest upon a single investigation of such a question at but one point of time in one single year, most persons will allow their opinions to be swayed by general considerations apart from the narrated observations. We offer a few thoughts on the subject without attempting to give it a full discussion.

The fact that the cold of the globe is dependent on the distribution of the land, so well illustrated by Lyell in his geology, has an important bearing on the question. The immobile land, buried in snows over the north is a fixed repository of cold, while the mobile waters are modified by currents. Consequently, if the Polar Sea is an archipelago like that of northern North America, it is hardly a possibility that the waters should be clear of ice; we may say positively that they could not be open. The frozen icy lands would ensure an intense cold, and a frozen sea between. On the contrary, if the sea is without land for a radius of twenty degrees, that is, within the circle of 80°, and the whole is one area of ocean, 1200 miles in diameter, we cannot assert, on the ground of the facts in Arctic America, that this great body of water would be frozen over. The free ingress of the Atlantic gulf stream along

by Spitzbergen (well shown by Dove's charts), and the free passage it would then have across to Behrings Straits, would obviously make so ready an interchange of temperature that we might well hesitate before pronouncing that the polar ocean would be an icy one.* It would have half the breadth of the Atlantic and make a large body of water to cover with ice. In addition, we have to consider that besides the source of heat from the Atlantic, the ocean, even within the Arctic circle, has at some depth, not very great, a temperature of 40° F.; for an isothermal plane of 40° bends around the globe within the ocean, from pole to pole, and no temperature colder than this exists below it, this being the maximum cold found by sounding in the tropics, and a temperature reached at some greater or less depth in the polar regions. Now as this substratum temperature is due to the pressure and the waters above are correspondingly affected, this cause must have some influence over the power of the cold of the atmosphere to freeze deeply the waters.

We may therefore safely conclude that so vast a polar ocean, if unencumbered by land, would be to a great extent a clear sea.

* We repeat in this place a woodcut copied from one of Dove's charts (in his Verbreitung der Wärme, &c., 1852) reduced one-half in diameter. It gives an idea of the position of the isothermals; and we have added the opening (K) at the head




of Baffin's Bay towards the Polar regions, along which Dr. Kane made his explorations. The temperature in Fahrenheit degrees (the *mean January* temperature) is given upon each of the lines, the difference between any two adjoining being 9° Part of the known lands north of North America are not represented. See also, in connection, the isothermal chart in volume xv of this Journal.

In this connection we may add farther, that were the globe without land, a universal ocean, it would probably be without ice even in its Arctic and Antarctic seas. Its mean temperature might be little different from the present, or near 58° F., but its range would be small compared to what it is under existing circumstances.

But have we any good grounds for supposing that the polar sea is unencumbered by land? Here is the embarrassing point in the hypothesis. We have seen that the narrative of Dr. Kane, allowing the facts stated all the weight they can demand, only suggest that the part of the polar circle between the pole and the coasts of Greenland and Nova Zembla may be open or unfrozen; and this is the part in which the sources of heat mentioned would act most decisively, being that into which the Gulf Stream flows. Greenland may stretch eastward towards a point north of Spitzbergen and so be the occasion of ice where Parry made his sledge excursion; while a little more to the east beyond this the ocean may have its free play northward. The oceanic isothermal lines laid down by Dove on his charts correspond with this idea, for the warmest part of the arctic circle is the half which is north of Spitzbergen; moreover, the long loops or flexures in the isothermals stretch up in winter northeast between Nova Zembla and Spitzbergen, with no bend up between Spitzbergen and Greenland; as if the former were the free direction for the waters. This course along the north Asiatic coast is mainly due, beyond doubt, to the eastern tendency in the waters; but yet we might expect an expansion to the northward by Spitzbergen if, there, lay the open channel pole-ward. Again the degree of cold for any place in America depends mostly upon the amount of land to the northwest of it. Now we find that in the coldest months, February and March, taking as data the deductions made by Mr. C. A. Schott from Dr. Kane's and other Arctic observations, the meridian of greatest cold is near the meridian 85° or just west of the head of Baffin's Bay, where Mr. Schott's chart gives −41 as the mean temperature for March. Now were the region that lies to the north and northwest of this, an open sea, it would be incredible that so low a temperature should exist along this meridian; but if an archipelago, or if there is at least a moderate proportion of land towards the poles, it then would be just that vast ice-house that in connection with the great continent of Greenland would aid in locating the point or meridian of extreme cold for America where it is actually found. Mr. Schott remarks on this point, that the extreme cold of Rensselaer Bay and Wostenholm, "point most conclusively to either a considerable northern expanse of Grinnell Land on one side and an eastern extension of Washington Land (northern Greenland) on the other, or to a

considerable elevation of the interior on both sides of the channel above its level."

It appears from the records kept, that the winds at Rensselaer harbor for January, February and March were mostly from between south and east. But in the former cruise, the observations in Baffin's Bay for the same month were generally between north and west; and as these were registered at sea remote from the land, they may give most correctly the prevailing atmospheric movement in winter for that region of the globe. North and northwest winds were found to be the most prevalent in the same months by Parry and Ross.

A review of the general considerations bearing on the temperature of the arctic regions, incline us therefore to believe in an open sea—comparatively open at least in some years—in the part of the polar circle towards Spitzbergen or Nova Zembla, the part to which the narrative of Dr. Kane relates. But we doubt strongly whether the other half is free from land or ice; and certainly there must be ice, if there is much land within it, or, in other words, if it is an archipelago.

The rocks, of the coast between Rensselaer harbor and the great Humboldt glacier, were stratified limestone, red sandstone, feldspathic and often porphyritic granite, passing into gneiss, and in some places trap. The limestone and sandstone formed lofty cliffs, averaging 900 feet in height. Hakluyt Island in latitude 77° 20′, presents on the coast a coarse red sandstone in nearly horizontal strata, while in the back country the rocks were in broken pyramidal shapes, appearing to be "greenstone."

The peaks of Greenland from the south cape to Disco, in latitude 70°, vary in height from 800 to 3200 feet; those of Pröven, latitude 71°, 2300; and those in lat. 76° 10′, 1380 to 1800 feet.

A large trap-dyke is described as intersecting the island of Disco, in latitude 70°, in an east-northeast direction, and crossing the channel of Waigat, separating it from the main land; and Dr. Kane speaks of its parallelism with the trap of Lake Superior. The other rocks of the region are syenitic gneiss, argillaceous and chloritic slates, with trap and amygdaloid. The dip of the slates at one point was 25° to the northeast.

The volumes of Dr. Kane also contain tables of meteorological observations, and of magnetic dip and intensity; notices of auroras; a plate of maps by C. A. Schott, giving the isothermal lines for the arctic regions north of America for each month of the year; a list of plants collected by Dr. Kane on the coast of Greenland and remarks, by Elias Durand; besides tables of geographical positions. His statements respecting the freezing of different substances by the extreme cold he encountered are of

much interest, but he intimates that a complete report on the subject and also on other points of science, including the geology, will appear elsewhere, and we trust that it may yet be published from his papers.

The wide discrepancies ascertained in his spirit thermoneters at very low temperatures may be considered an observation of interest, as they will lead to precautions in future in the construction of such instruments. We close by a citation on this subject from the Appendix, 2d Expedition, pp. 405, 406, and also a table of temperatures, p. 425.

"Except in naval expeditions, Arctic temperatures, whether Asiatic or American, have been recorded with a limited number of instruments. The results of these must be received with extreme caution; for the differences which alcoholic thermometers exhibit at temperatures below the freezing point of mercury are so varying as to require a large number of comparisons and upon many instruments, to determine their proper correction. It was not uncommon for thermometers, which had given us correct and agreeing temperatures as low as $-40°$, to show at $-60°$ differences of from fifteen to twenty degrees. Such too was the case with the well-constructed instruments of Sir James Ross at Leopold Harbor.

"To give an example of this, I may refer to the record of six thermometers, suspended near each other as above described, and observed for purposes of comparison at noon, February 5, 1854, $-71°$, $-63°$, $-54°$, $-53°$, $-50°$ and $-50°$. All of these at temperatures above $-40°$ agreed within $1{\cdot}8°$, and were selected as the most consistent of nearly thirty spirit thermometers.

"At 9 A. M. of the same day, eleven similar thermometers, gave under like circumstances, a mean of 68°, the extreme readings being $-56{\cdot}4°$ and $-80°$. For the purpose of obtaining the most probable temperature from these conflicting records, my first impulse was to reject the lowest (coldest) extremes, and take the mean of those which accorded best; but upon advising with our astronomer, Mr. Sontag, I determined to take the mean of all, without rejecting any,—the view which he took being simply that those instruments which indicated the extremes in the low scale had never in temperatures above $-40°$ shown any anomaly which deprived them of an equal claim to confidence with the rest, and that there was no reason *a priori* to consider the results which they gave as less probable than those shown by the others. * * * *

"Our thermometers were made with great care by Taliabue, of New York. But, independently of other mechanical sources of error, I am obliged to say that I do not regard the contraction of colored alcohol at very low temperatures as sufficiently investigated to enable us to arrive at the causes or the quantity of error. In most of the spirit thermometers the uniform thickness of the tube was tested before leaving New York; and the freezing of carefully-distilled mercury which I had taken with me for the purpose, gave excellent determinations of absolute temperature.

"But it may not be uninteresting to state that the freezing-point of this metal varied between $-38{\cdot}5°$ and $-41{\cdot}5°$, and that its rate of contraction as a solid was so uniform, that in our long and excellent 36-inch

standards it descended after freezing as low as −44°. This result is in accordance with that obtained by Sir Edward Belcher, whose experiments go even further than my own,—the mercury having been observed by him to descend as low as 46° below zero."—*Second Expedition*, pp. 405, 406.

*Synopsis of mean monthly readings of atmospheric temperature and pressure, and of observed maxima and minima temperatures.*

| Date. | Temperature of Air. | | | Barometer. | Attached Thermometer. |
|---|---|---|---|---|---|
| | Mean. | Maximum. | Minimum. | | |
| | o | o | o | Inch. | o |
| 1853, June, ..... | +48·63 | +70·0 | +35·0 | 29·890 | +55·73 |
| July ..... | +37·83 | +51·0 | +30·0 | 29·727 | 68·83 |
| August..... | +33·41 | +46·0 | +25·0 | 29·661 | 68·92 |
| September.... | +17·16 | +32·0 | − 2·2 | 29·678 | 55·86 |
| October ..... | + 0·55 | +17·8 | −23·7 | 29·801 | 69·76 |
| November .... | −23·01 | + 0·2 | −43·2 | 29·726 | 34·35 |
| December .... | −25·99 | +15·8 | −45·7 | 29·842 | 36·36 |
| 1854, January ..... | −30·24 | +11·0 | −59·9 | 29·461 | 29·66 |
| February ..... | −33·60 | −11·3 | −68·0 | 29·642 | 24·69 |
| March..... | −38·09 | + 0·9 | −55·6 | 29·760 | 14·52 |
| April ..... | − 8·60 | +14·3 | −43·0 | 29·981 | 29·71 |
| May ..... | +12·89 | +39·4 | − 8·7 | 29·970 | 51·62 |
| June ..... | +29·23 | +41·9 | +17·7 | 29·780 | 53·98 |
| July ..... | +38·40 | +53·9 | +27·6 | 29·784 | 46·67 |
| August..... | +31·35 | +48·9 | +19·1 | 29·711 | 37·66 |
| September.... | + 9·81 | +26·6 | − 8·9 | 29·682 | 41·22 |
| October ..... | −10·54 | +22·9 | −41·0 | 29·743 | 51·60 |
| November .... | −23·03 | + 4·3 | −49·9 | 29·855 | 51·98 |
| December .... | −37·74 | − 8·4 | −61·4 | 29·728 | 49·98 |
| 1855, January ..... | −28·61 | +25·2 | −69·3 | 30·141 | 49·31 |
| February ..... | −21·21 | +19·6 | −53·9 | 30·095 | 51·88 |
| March..... | −33·97 | + 2·3 | −56·1 | 29·795 | 67·17 |
| April ..... | −14·00 | + 8·9 | −42·3 | 29·904 | 59·93 |
| Autumn, (1853) ..... | − 1·77 | +32·0 | −43·2 | 29·735 | 53·32 |
| Winter, (1853–54)... | −29·94 | +15·8 | −68·0 | 29·648 | 30·24 |
| Spring, (1854)..... | −11·27 | +39·4 | −55·6 | 29·904 | 31·95 |
| Summer, (1854), .... | +32·99 | +53·9 | +17·7 | 29·758 | 46·10 |
| Autumn, (1854) .... | − 7·92 | +26·6 | −49·9 | 29·760 | 48·27 |
| Winter, (1854–55)... | −29·19 | +25·2 | −69·3 | 29·988 | 50·39 |

Difference, (Summer and Winter,) 62·93°
" warmest and coldest m'nth, 76·49
" maximum and minimum, 123·20

Mean of the year 1854.

| Temp. of Air. | Barometer. | Attached Therm. |
|---|---|---|
| −5·01° | 29·7581 inch. | +40·27° |

The maximum of temperature was +53·9°, and occurred on the 4th of July, 1854.
The minimum in 1854 was −68·0°, and occurred on the 5th of February.
In 1855 it was −69·3° on the 7th of January.

From September, 1853, to April, 1855, (inclusive,) the observations were made at nearly the same place; hence the means of the same months in 1353, 1854, and 1855, would be combined for the mean annual temperature and the mean annual height of barometer given in the following table.

Lat. 78° 37′ N., lon. 70° 40′ W. from Greenwich.

| Month. | Mean temperature of air. | Barometer. | Attached Thermometer. |
|---|---|---|---|
| | ° | inch. | ° |
| January | − 29·42 | 29·801 | + 39·48 |
| February | − 27·40 | 29·868 | 38·29 |
| March | − 36·03 | 28·777 | 40·84 |
| April | − 11·30 | 29·942 | 44·82 |
| May | + 12·89 | 29·970 | 51·62 |
| June | + 29·23 | 29·780 | 53·98 |
| July | + 38·40 | 29·784 | 46·67 |
| August | + 31·35 | 29·711 | 37·66 |
| September | + 13·48 | 29·680 | 48·54 |
| October | − 5·00 | 29·772 | 60·68 |
| November | − 23·02 | 29·790 | 43·16 |
| December | − 31·86 | 29·785 | 43·17 |
| Year | − 3·22 | 29·805 | + 45·74 |
| Spring | − 11·48 | 29·896 | 45·76 |
| Autumn | − 4·85 | 29·747 | 50·79 |
| Summer | + 32·99 | 29·758 | 46·10 |
| Winter | − 29·56 | 29·818 | 40·31 |

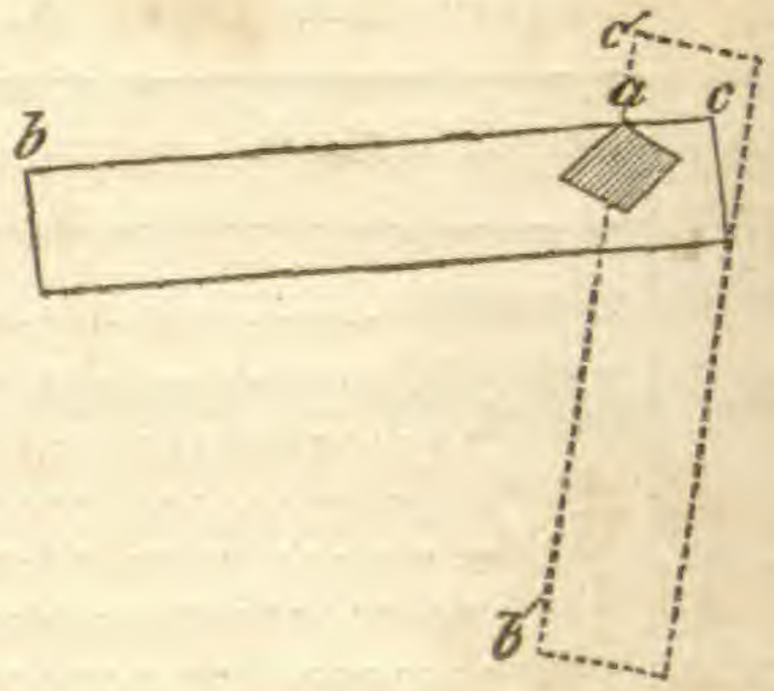
"The preceding tables show that the mean temperature of the year 1854 was 1·79° colder than the mean temperature of the year as derived from twenty months' observations."—p. 425.

The scientific facts which have been cited from the volumes of Dr. Kane, are but a selection of comparatively dry detail from a work full of incidents in illustration of the topics we have discussed. And whatever the subject, whether icebergs, glaciers, or stormy seas, Esquimaux, walruses, or polar bears, or their own personal life when frigid night settled about the camp, or when they sallied forth to battle with stern nature and raise the standard of victory over her frowning heights, the varied scenes stand out in all their reality before the reader of his stirring words. Although the hero of the Arctic has since fallen by disease, his triumph was complete; and in his death, it was followed, as we may trust, by another more glorious triumph above all the clouds and cold and darkness of earth. J. D. D.

---

## Art. XIX.—*A method of measuring the Angles of Crystals by reflection without the use of a Goniometer;* by P. Casamajor.

The method of measuring the angles of crystals by reflection, is well known to be the most accurate that has been proposed. But goniometers by reflection are costly instruments and, besides, not always at hand. For these reasons I have devised the following as a substitute; and I here announce it, believing that it will prove useful to travelling mineralogists who have not goniometers with them, and to students who do not wish to incur the expense of buying an instrument.




To measure the angle of inclination of two faces of a crystal, I use a rule $b\,c$ with a straight edge. On one end the crystal is placed on a piece of wax. The eye is then brought near to the crystal until a clear vertical line is seen, such as a vertical bar of a window. The crystal is then moved on the wax until the image reflected be also vertical. The same is then done with the other face, and when the reflection of the bar is vertical on both faces, the crystal is adjusted, which is done after a few trials. The rule is then placed on a sheet of white paper, which is placed on the edge of a table. The paper must not be moved during the operation. The eye is again placed near one face of the crystal which is turned until the reflected image is made to coincide with some other vertical line seen directly. Then a pencil is passed along the straight edge and a line made on the paper. Under the edge of the crystal a mark is made to fix the point that is to be the vertex of the angle. The rule is then turned until the reflected line on the other face and the line seen directly coincide. In this second position, the vertical edge of the crystal must be again over the mark made under it in the first position. This is to oblige the eye to place itself in the same position that it had at first. A line is then drawn along the edge and the angle of these two lines is the supplement of the angle between the two faces of the crystal. This needs no proving as the principle is the same as in the case of Wollaston's goniometer.

The angle on the paper can be measured by a protractor, or in any other convenient way.

If the operator has no protractor but has a table of natural or logarithmic cosines, the best way is to make a triangle and to measure its three sides. Calling $A$ the angle measured by the two lines, $a$ the sides opposite to it, $b$ and $c$ the adjacent sides. Then $a^2=b^2+c^2-2bc\cos A$. When the angle $A$ is acute the cosine is positive; when it is obtuse the cosine is negative. If we take $b=c$, we have

$$a^2=2b^2-2b^2\cos A$$

and if $b=1$

$$a^2=2-2\cos A.$$

Then when the angle is acute,

$$\cos A=\tfrac{1}{2}(2-a^2)=1-\tfrac{1}{2}a^2,$$

and when the angle is obtuse,

$$\cos A=\tfrac{1}{2}a^2-1.$$

Example: a crystal of Iceland Spar gave an angle by the two positions of the rule. Each side adjacent is made 1 decimeter long. The side opposite measured 1·215 decimeter, the square of which is 1·47622, whose half is 0·73811

$$\cos A = 1 - 0{\cdot}73811 = 0{\cdot}26189.$$

The angle corresponding to this cosine is 74° 50′; the supplement is

$$180° - 74°\ 50' = 105°\ 10'.$$

Although any rule with a straight edge will answer the purpose, a metallic rule is to be preferred, because its weight makes it more steady. Instead of a sheet of paper the top of a white marble mantle-piece may be used. It has the advantage of being immovable, and pencil marks on it are easily erased.

Many ways might be proposed for adjusting the crystal. I stick wax on the ruler and adjust the crystal with the hand. Wax adheres well to brass, ivory and steel, not so well to wood.

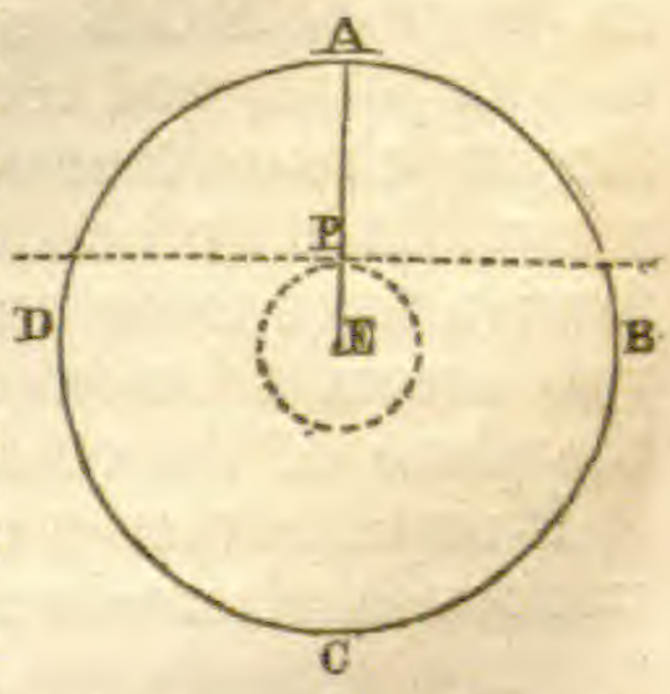
The measurement by a rule is not proposed as better than by a goniometer; but when the operator has not a good instrument, he will find it a simple and accurate method. An angle can be read to within 15′ with a good protractor of 1 decimeter radius, or by measuring the side opposite to the angle $A$ and calculating $\cos A$.

---

## Art. XX.—*Explanation of the Motion of the Gyroscope;* by H. A. Newton.

The instrument called a *gyroscope*, as made in this country, is a heavy wheel suspended in a ring. The wheel can revolve on its axis in the ring, and the whole can move in any way about a fixed point in this axis. The instrument differs from Foucault's gyroscope in that its center of gravity and the fixed point do not coincide. In what follows, the ring and the effect of friction are disregarded.

Let A B C D be a section of the wheel through its center of gravity E, and perpendicular to its axis. Designate by O the point of support, O E will be the axis of the wheel.




If from a state of rest (OE not being vertical), the wheel is left to the action of gravity, it will vibrate back and forth like a pendulum. But when a rapid rotation is given to the wheel, and it is then left to the action of gravity, we find that it no longer swings like a pendulum, but O E commences a slow revolution about a vertical line through O. The direction of this motion is the same as

that of the lower side of the wheel. The line O E thus describes a conical surface.

The case in which this conical surface is that of a right cone, and is described by a uniform velocity of O E, is the only one I shall consider. It is proposed to show, that if such a motion is produced by a force applied at E, that force must be constant, and in the vertical plane P O E.

For this purpose let the motion in question be considered as generated in a different way. About E as a center, with some radius P E, describe a circle in the plane A B C D. Through P the highest point of this circle let a horizontal plane be drawn cutting a vertical line through O in Z, join P Z. About Z as a center describe in this plane a circle with P Z as radius. The first of these two circles is in the wheel and moves with it. The second is fixed in space. If the circumference of the first rolls on that of the second, O E will describe a right cone.

Now by varying the ratio P E : P Z, we can vary at pleasure the ratio of the velocity of rotation of the wheel about its axis to that of the plane P O E about O Z. Any motion, therefore, like that we have to consider, may be generated by the rolling of one circle upon another.

The point of contact P of the two circles is always in the same vertical plane with O E. This point is *for the instant* at rest, and the body may therefore be considered as revolving about O P.

By this rotation the center of gravity E would describe a circle about P, if neither *centrifugal forces arising from rotation*,* nor foreign forces acted on the body. The force at E must be such as will change this circular into a horizontal motion.

This must be a downward force. For, the instant after O P is at rest P moves downward, and to produce this motion a force in the plane P O E is necessary. It must also be constant. For, the circle which E tends to describe is always of the same radius.

Now besides foreign forces we must consider the centrifugal forces arising from the rotation. The resultant of these must be in the plane P O E, since the body is symmetrical with respect to that plane, and revolves about an axis in it. It is constant, for the circumstances under which it is produced are ever the same. It may be downward or upward. In either case, the foreign force to be applied at E, being the sum or difference of two constant forces, is itself constant. It must evidently be in the plane of the other two, that is, in the vertical plane P O E.

It requires then a constant downward force at E to produce a uniform horizontal motion of the center of gravity.

* The meaning of this phrase may be explained by an example. When a wheel revolves on an axis inclined to its plane, the rotation produces a tendency to increase the angle of inclination. The causes of this tendency are the so-called *centrifugal forces.* They are treated as *forces*, because, in the motion of a free body an opposing *force* must be applied, if the axis of rotation is to remain unchanged.

This investigation supposes the motion of E horizontal. This is not usually the case. With a given rotation about a given axis O P in the vertical plane through O E, we have seen that there is needed a certain determinate force at E to produce horizontal motion. Conversely then, for a given force at E, as gravity, and a given initial rotation about O E a determinate horizontal impulse must be given to E, that is a determinate line O P in the plane P O E must be at rest the first instant, if horizontal motion is to be produced.

With any other initial impulse the motion is much complicated. The resultant of the centrifugal forces is no longer in the vertical plane P O E. Its direction is constantly varying. The determination of the motion in this general case I do not propose to undertake. My object has been to show in the simplest case, and by methods not involving the processes of analysis, the action of a vertical force producing horizontal motion of the center of gravity.

---

ART. XXI.—*Correspondence of M. Jerome Nicklès, dated Paris March* 7, 1857.

*Academy of Sciences. Distribution of Prizes.*—Conformably to usage, at the annual meeting of the Academy opening the new year, a eulogy was pronounced by the Perpetual Secretary on one of the former members; and this year, the subject was the mathematician Coriolis, who died September 18, 1843. His titles to this honor and the remembrance of posterity are of more than one kind. He contributed largely to the progress of applied mechanics, by presenting in a new light the subject of *living forces;* in defining precisely what should be understood by *the work of a machine;* in being the first to substitute for the consideration of bodies taken in mass, the consideration of them as composed of distinct molecules.

Prizes were distributed by the Academy for different questions that had been previously proposed, the more important of which we mention, premising that the subjects were open to the scientific men of all countries.

The great prize for mathematical science was given to a German, M. Kummer, for his Researches on complex numbers consisting of roots of unity and of whole numbers. One of the grand prizes in physical science was given to Professor Bronn at Heidelberg, for an extensive work made in reply to the following questions:—1. What are the laws of distribution of fossil organized bodies in the different sedimentary strata as regards their order of superposition; 2. What as to their successive or simultaneous appearance or disappearance; 3. What the rela-

tions which exist between the present condition of the organic kingdoms and that of earlier time.

Another prize, which had been held out ever since 1847, was given to Lereboullet, Professor of Zoology at Strasbourg. The subject was the following: *To establish, by studying the development of the embryo in two species, taken one from among the Vertebrata, and the other either from the Mollusca or Articulata, the basis for comparative embryology.* It was a question requiring long investigation, and was treated by Lereboullet in his usual thorough style. The Academy awarded him a medal of gold, valued at 3000 francs.

The prize in Experimental Physiology was divided between Messrs. Waller, Davaine and Fabre; the first, for his experiments *on the ganglions of the rachidian nerves;* the second, for his experiments *on the Anguillula Tritici;* the third, for *researches on the action of the poison of the Cerceris* (*Hymenopterous insects*) *on the nervous ganglionary system of insects.* This is not the place to analyze the interesting researches of these physiologists. But we may say however that M. Fabre brought out the fact that the larves, with which the insects of the Cerceris family provision their nests for the nourishment of their own young, are struck with a kind of paralysis, which permits of their living for a long time while depriving them of the faculty of feeling or moving. This species of anesthetic condition is produced by the puncture of one of the thoracic ganglions by the sting of the Cerceris; and M. Fabre has succeeded in producing this condition at will by introducing a little ammonia into the nervous ganglionary system, an effect which he has repeated in other insects.

With reference to the expenses of carrying on these researches, the Academy contributed a certain sum to each, and also divided between them the prize of 5000 francs.

As usual, the Academy found nothing to compensate or encourage in physics, chemistry, or in mineralogy, if we except a prize of 2500 francs given to M. Schroetter for the discovery of the isomeric state of red phosphorus. It was decreed by the Commission for the prizes relative to the insalubrious arts, for the year 1856, a Commission consisting of MM. Rayer, Dumas, Pelouze, Boussingault, Combes and Chevreul. We say it, to the honor of this Commission, that the prize was declared not solely for the discovery of a non-poisonous phosphorus which could be employed in preparing matches in place of ordinary phosphorus, but also in addition to this, because of the scientific merit of the discovery.

This same Commission decreed 2500 francs to a workman named Chaumont, the inventor of a machine for separating the long hairs of the skin of the rabbit from the short and fine hairs which are exclusively used in making the felt of hats. In France, this operation is called "éjarrage," because the long

hairs are called "jarres" by tanners. The work had been done by hand, and was very injurious to health, as the workmen were exposed to breathing an atmosphere charged with particles of hair; and this evil is mostly removed by the new invention, while at the same time the method is more economical, as each machine, directed by a single workman, does the work of six females.

The commission on prizes in medicine has given delight to many; more than 50,000 francs were distributed by them to reward discoveries or useful applications in the healing art. Among the laureates, there are

Dr. *Simpson* of Edinburgh, who, as stated by Mr. Flourens, first introduced chloroform into anesthesis for surgical operations.

Dr. *Middeldorp* of Vienna (Austria) for the application of the galvano-caustic in certain surgical operations, to which we alluded in our letter published in the number of the American Journal for November, 1856.

Mr. *Brown-Sequard*, for having shown that various lesions of the spinal marrow in the Mammalia, may be followed after some weeks by a convulsive epileptiform affection, produced either spontaneously or by excitation of the ramifications of the fifth pair of nerves on the side corresponding to that of the lesion.

Mr. *Delpech*, for making known the accidents occurring among workmen in the india-rubber business from the inhalation of sulphuret of carbon.

The Cuvierian prize, which is assigned every three years to the author of works in Natural History, was given this year to Prof. Richard Owen, who for more than twenty years, through works of great number and of elevated character, has contributed largely to comparative anatomy and palæontology. This prize was first given to Prof. Agassiz for his work on fossil fishes, and the second time to Prof. Müller of Berlin, for his researches on the structure and development of Echinoderms.

It is thus seen that in this year, as in others preceding, *foreign* men of science have taken a large part of the prizes, a fact highly honorable to the Academy of Sciences, showing that a right to its munificence does not rest in being a Frenchman, but in being worthy of it through actual labors.

Among the prizes to be given in January, 1858, there will be one on the application of steam navigation to naval operations. Three years since a similar prize was given, as we have mentioned. The new prize of 6000 francs aims to bring out new improvements especially with reference to the diminution of the amount of fuel for ships of war. Other improvements may also come from the combination of wind and steam. Moreover, naval architecture has not yet given in its last word. Engineers and men of science of all nations are invited to a competition, in which the desire is to reward inventions or improvements that

are substantiated by experience. The Academy leaves to the competitors an unlimited range, and wishes to secure some great step of progress, which shall be demonstrated practically, and if possible, also theoretically.

*Society for the Aid of the Friends of Science.*—There has just been established at Paris a society, the importance of which has been demonstrated by recent events. It is not forgotten that Laurent and Gerhardt died leaving a wife, and children under age, without a competence. Some subscriptions set on foot immediately, ameliorated somewhat their unfortunate condition, without proving very efficacious.* The society which has just been organized, has for its end, the establishment of a fund for the benefit of the families of men of science who may die without fortune. Their object is thus stated:—"The undersigned, considering that the cultivation of the sciences cannot be too much encouraged, and that those who give themselves to it with zeal sometimes so exhaust their resources as to leave their families at death in need, have resolved to form a society whose object shall be to give aid to the unfortunate that may be worthy of their consideration."

This society is formed under the patronage of M. Thenard, and the prominent savants of France have joined it. The subscription is ten francs per year. Independently of these subscriptions, the society will receive with proper recognition, gifts or bequests which may be made to it.

*History of Science. Iron bridges.*—On the occasion of a claim of priority raised by Mr. Ross, a bibliographic investigation was commenced respecting the history of iron bridges. Mr. Ross, in fact, wrote to the Academy on the subject of a model of a bridge entirely of iron, which was presented to that society in 1787 by an Englishman of the name of Payne. A record of this has been found in the archives of the Academy. A commission, consisting of Bossut, Borda, and Rochon, at the session of the 29th of August, 1787, made a favorable report on this project. The plan was for a single arch of 400 feet span, and it was to have been made partly of wrought iron and partly of cast. In the historical notice which forms the preamble of the Report, the commission, after mentioning different bridges of iron that had been only projected, dwelt at some length on a bridge which

* We alluded in 1853 to the subscription undertaken in that year for the widow and children of Laurent. Another has just now been started for the widow and three children of Gerhardt: it is a subscription of a new kind, under which the minimum contribution is 100 francs; and in exchange for this sum, the subscriber receives the Treatise on Organic Chemistry which Gerhardt was bringing to a close when he died. Each copy is accompanied with a notice written by M. Cahours and an autograph of Gerhardt. A similar subscription has been opened in London, in Switzerland, in Germany, and in the different Faculties of France. I feel confident that the scientific men of the United States will not be behind their confrères of Europe.

had been executed some years before—the bridge of Colebrook-Dale, thrown over the Severn. It consisted of a single arch of 100 feet span, and was constructed about the year 1779. It was built entirely of cast iron, and the commission state that at the time at which they wrote, it seemed to have suffered nothing from use or from alternations of heat and cold. It should be added that at the same session, when this report was presented, a locksmith of Paris, named Clement, brought forward plans for different parts of an iron bridge, which he proposed to build.

The last paragraph of this Report is interesting, as it shows the state of the iron industry in 1787. "We conclude, in view of all that has been exhibited, that the construction is simple and solid, and fitted to resist the weight and wear to which it will be exposed, and that it deserves to be tried: and finally, that it will furnish an example of the application of a metal which has not been enough used on a great scale, although on many occasions it has been employed with success."

Could the savants Bossut, Borda and Rochon return to the world they would see their views fully realized.

*Astronomical News.*—The prize established by Lalande for astronomical discovery, has been divided this year between Messrs. Chacornac, Goldschmidt, and Pogson of Oxford; the first for his discovery of two planets, Leda and Letitia, on the 12th of January and 8th of February, 1856; to the second for the discovery of Harmonia and Daphne, the 31st of March and 22d of May, 1856; and to the last for the discovery of the planet Isis, the 42d of the asteroids; the first four of these were earliest seen at Paris, the last at Oxford in England.

When Sir John Herschel was at the Cape of Good Hope, he was much troubled by his speculum; it tarnished constantly, and after five or six days was unfit for service. The same difficulty is encountered in all observatories. In his position as physicist to the observatory, M. Foucault has been led to take up the subject, and he has proposed as an improvement, that, for the *metallic* speculum, one should be substituted made of glass well polished and coated with silver after Drayton's process, that is, by the slow reduction of the nitrate of silver by means of an essential oil. When taken from the bath, the coating of silver is dull, but it is readily polished by friction with a skin covered with a little English red: it acquires, in a few moments, a brilliant lustre and gives fine reflections.

Although we cannot affirm that the lustre of this new speculum will be of long duration, there is at least reason to hope well of it, since silver is less alterable than copper and bronze; but even if it becomes dull it is as easily polished as at first.

*Electric Telegraph. Submarine cable across the British Channel.*—In consequence of a terrible gale, the two submarine cables

between the coast at Calais and Ostende and the English coast at Dover was broken by a vessel dragging its anchor over them. For some time after this, England had no communication with the continent except by the way of Holland. The Calais connection has now been reëstablished. The engineer charged with this work made use of the opportunity to examine the cable at the place of rupture, and he states that the conducting wires were perfectly uninjured in their envelop of gutta percha notwithstanding the five years' immersion in sea-water.

*Scientific Voyages.*—Since the scientific expedition was sent out last year to the northern seas by the French prince, an Austrian prince has projected a similar expedition; and more wise than his confrère of France, he has equipped it with a scientific corps. The corps will consist of distinguished and competent men, such as Dr. Scherzer, Moritz Wagner, Frauenfeld, Hochstetter, Zelebor.

The following is the plan of the voyage. The frigate leaves Trieste early in March, 1857. It will visit the principal ports of South America, double the Cape of Good Hope, touch at Ceylon, visit the English, French and Dutch possessions in India, the accessible ports of China, thence pass to Oceanica, touch at New Caledonia, Australia, New Zealand, Tahiti, etc., coast along Central and South America, and traversing the straits of Magellan, return to Trieste, in the spring of 1859. This is the first Austrian Exploring Expedition. The vessel is the frigate Novara, of 44 guns.

*Chemical Facts. Different states of Sulphur.*—Among the chemical researches in France during the last few months, we would refer to those of Berthelot on sulphur, the allotropic states of which element have appeared to be numerous and varied. Berthelot reduces all to two principal states, viz. that of *octahedral sulphur*, soluble in sulphuret of carbon, and that of *amorphous sulphur*, insoluble in this sulphuret. The former he calls *electro-negative* sulphur, for it acts always as a supporter of combustion, and separates from compounds in which it plays an electro-negative part (as SH, $S^2C$). The insoluble sulphur, on the contrary, is combustible or *electro-positive*, and separates from compounds in which it plays an electro-positive part ($SO^2$, $SO^3$, $S^2O^2$, $S^3O^4$). Under a similar relation, Berthelot brings with reason the allotropic states of selenium and phosphorus, which have, as is known, each a state soluble and insoluble in sulphuret of carbon. The two conditions of oxygen, ozone and ordinary oxygen, are to be considered as dependant on different electrical states, the ozone electro-negative, and ordinary oxygen electro-positive.

Now that the true principle has been indicated, it will be easy to find analogous facts, for it is one that will prove to be fertile in its applications.

*Magnesium, Boron, Aluminium.*—We owe to M. H. St.Claire Deville a series of facts of great interest, to which we can here only allude.

Magnesium is volatile like zinc, and may be as easily distilled; it also fuses at the same temperature, and burns with a bright flame, in the midst of which some points of indigo blue may be distinguished; at the same time it disengages a white cotton-like oxyd, like that of zinc, which is fixed and infusible. These are but a few points from the researches of Deville and Caron, at the laboratory of the Normal School.

The results respecting *boron* are communicated by Deville and Wöhler. Wöhler recently visited Paris to compare his results with those of Deville. It appears that crystallized boron is akin to the diamond; it has very nearly its hardness, and may be of great use when hard stones are wanted in watch or clock making, or their powder for grinding, especially grinding glass. Crystallized boron is obtained by reducing boric acid by means of aluminium; it forms borate of alumina and boruret of aluminium, and from the latter at a lower temperature boron separates, just as graphite in the cooling of fused iron.

*Waters of Artesian Wells.*—On examining the waters of the Artesian well of Grenelle with reference to the gases present, M. Peligot has ascertained that they contain not the least trace of air. Subterranean waters ought therefore to be *aerated* before being used as an aliment, and accordingly they are about to construct at Grenelle a species of tower, from the top of which the water will descend in innumerable threads, so as to present as much surface as possible to the air.

*Photography. The regular Universal Exhibition by the French Photographic Society.*—This exhibition is open and is remarkable for the magnificent display of pictures it affords: and they are numerous in spite of the severity of the jury of admission. All the processes are represented, from the Daguerrian plate to dry collodion, including moist collodion, albumen, albuminized collodion, waxed paper, chloridized albumen, etc., with all the methods of fixing pictures employed, and all kinds of photography. There are portraits, landscapes, buildings, panoramic views, etc. Only photographs from living nude subjects, called "Academies," are excluded.

The arrangement of the pictures is according to the nations contributing them. Visitors stop in crowds before the photo-galvanographs exhibited by M. Pretsch, representing objects such as the Venus of Milo, the Cathedral of Strasburg, with a finish and beauty which would make us believe that they had been touched up with a graver, if men of truth had not on their honor affirmed the contrary.

The sea scenes of Mr. LeGray are much admired. They represent ships under way with full sail, a stormy sea, clouds floating in the air and crossed by a beam of the sun, all instantaneously taken. There are also photo-lithographic pictures on steel exhibited by Mr. Nègre, and proofs on paper designed for transparent views, and printed in the photographic printing establishment of Blanquart-Everard de Lille. There are casts (clichés) obtained by means of collodion on gutta percha rendered transparent by a process invented by M. Perret, a modest workman of Paris. These sheets of collodion have colossal dimensions, being about a meter high and eighty-eight centimeters wide; they are nearly as light as a spider's web.

*Bibliography.*—At the book establishment of Hachette, at Paris, the following works, in 12mo, have appeared:

L. FIGUIER: *The Scientific and Industrial Annual*, containing an exposition of the scientific works, inventions, and principal scientific applications which in 1856 attracted public attention in France and other lands. A similar volume appears each year.

A. YSABEAU: *Gardening, or the art of making and keeping a garden.*

HERVÉ and DELANOYE: *Voyages in the ice of the Arctic Pole* in search of a northwest passage; extracts from different voyages.

LEONIE D'AUNET: *Voyage of a woman to Spitzbergen.*

T. DE LANOYE: *The India of the present era:* with an introduction giving a brief history of these regions so rich and interesting.

CH. DREYSS, Professor at the Lyceum of Versailles: *Universal Chronology*, followed with a list of ancient and modern states. This Chronology comes down to 1852.

A. CHERUEL: *Historical Dictionary of the Institutions, Manners and Customs of France.* 2 vols. of 564 pages in two columns. The work is preceded by an introduction which gives a chronological catalogue of the institutions, or the *public* life, and the progress of manners, or the *private* life, of the French.

---

## SCIENTIFIC INTELLIGENCE.

### I. CHEMISTRY AND PHYSICS.

1. *On a new biacid alcohol.*—LIMPRICHT has found that chlorbenzol, $C_{14}H_6Cl_2$, is the chlorid of a radical yielding a new bibasic alcohol analogous to Wurtz's glycol. The preparation of the pure alcohol is attended with difficulty in consequence of the facility with which it is converted into oil of bitter almonds, but Limpricht has prepared various ethers which leave no doubt as to the correctness of his views. Ethyl-benzol ether may be prepared by the action of chlorbenzol upon ethylate of soda. It is an oil with an agreeable odor and having the formula $\left.\begin{matrix} C_{14}H_6 \\ (C_4H_5)_2 \end{matrix}\right\} O_4$.

Aceto-benzolic ether is prepared by the action of chlorbenzol upon acetate of silver. It forms colorless crystals which have the formula $\left.\begin{matrix} C_{14}H_6 \\ (C_4H_3O_2)_2 \end{matrix}\right\} O_4$. The action of aqueous ammonia upon aceto-benzolic ether yields acetamid and hydrobenzamid. The author suggests that hydrobenzamid is tribenzolamin, $C_{42}H_{18}N_2{=}N_2\left\{\begin{matrix} C_{14}H_6 \\ C_{14}H_6 \\ C_{14}H_6 \end{matrix}\right.$, and that stilben may be the radical benzol, $C_{28}H_{12}{=}\left.\begin{matrix} C_{14}H_6 \\ C_{14}H_6 \end{matrix}\right\}$, and benzoin benzolic ether, $C_{28}H_{12}O_4{=}\left.\begin{matrix} C_{14}H_6 \\ C_{14}H_6 \end{matrix}\right\} O_4$.—*Ann. der Chemie und Pharmacie*, ci, 291.

[*Note.*—As there are few substances in organic chemistry more interesting or more important than the oil of bitter almonds, it appears desirable to have a single word for it in place of its present inconvenient appellation. I suggest the name *picramol* as appropriate and convenient. —W. G.]

2. *On the action of light upon chlorid of silver.*—Guthrie has instituted a few experiments which tend to show that the blackening of chlorid of silver by light, as supposed by Scheele, is due to the liberation of chlorine and the deposition of metallic silver. When dry chlorid of silver was exposed to light in a sealed tube, chlorine was found to be present in a free state. The blackening took place in benzol boiled so as to expel air. The gray mass of altered chlorid was heated with ammonia, which left a slaty grey substance which took the metallic lustre under a pestle, and was soluble in nitric acid and precipitated by chlorhydric acid, but not by ammonia. In another experiment the quantity of silver reduced and the quantity of chlorine set free were both weighed as chlorid of silver, and the weight found to agree as nearly as could be expected, also the quantity of chlorid of silver yielded by the metallic silver reduced agreed with the theoretical quantity. The blackening took place under nitric acid concentrated or dilute, and the quantity of chlorid found by the black matter agreed nearly with the amount of chlorid which should be yielded by pure silver.—*Quarterly Journal of the Chemical Society*, x, 74.

3. *On the use of the prism in qualitative analysis.*—Gladstone has studied the colors of various salts by means of the prism, and has made an interesting and valuable contribution to a branch of physico-chemistry heretofore too much neglected. The author employed in the analysis of liquids a wedge-shaped glass vessel, so placed that the line of light from the window traversed different thicknesses of the liquid and was then analyzed by means of a prism. The appearances as thus seen are easily transferred to paper, as Fraunhofer's lines are under favorable circumstances distinctly visible. As a general result, the author states that all the compounds of a particular base or acid have the same effect on the rays of light. Exceptions to this law occur, though very rarely. As it would not be possible to understand the author's special results without the aid of figures, and as our limits will not permit us to give all his details, we shall content ourselves with a sketch of the characters of the salts of a few metals. The difference in color between certain chromium salts vanishes entirely when the solutions are examined in the manner pointed out.

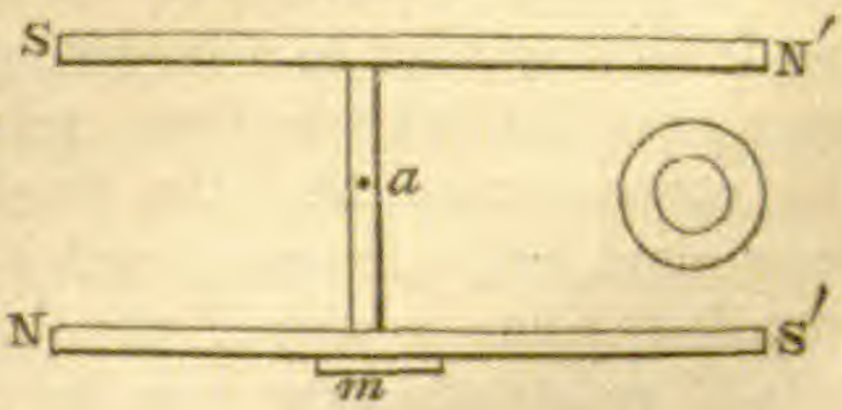
The red and blue solutions of cobalt do not greatly differ in their spectra, and the same is the case with the green and blue salts of copper. The ammonical salts of copper give however a very different prismatic appearance. All the salts of sesquioxyd of iron absorb the more refrangible rays, leaving the least refrangible to penetrate almost any thickness. The chromates exhibit a remarkable analogy in their spectra though sometimes very different to the eye, but there is a wide difference between the compounds of sesquioxyd of chromium and chromic acid. The general law laid down by the author is shown remarkably in the colors of litmus, the neutral acid and alkaline solutions of this substance yielding spectra which are only modifications of a common type. In compounds of two colored bodies the chromatic effect of the components persists so that it is often difficult to determine whether two bodies have combined or not. The author draws the following conclusions as of value in analysis. From the fact of the transmission of a particular ray we may infer that none of those bodies which usually absorb that ray are present in any kind of combination. The employment of the wedge and prism will often present some familiar spectral appearance which is at once distinctive, although the unassisted eye cannot determine the source of the color. The author in conclusion suggests that when a systematic comparison of different spectra shall have been made and regular tables of comparison constructed, the prism will take its place among the recognized instruments of the laboratory.—*Quarterly Journal of the Chemical Society*, x, 79. W. G.

4. *On the Disposition of Force in Paramagnetic and Diamagnetic Bodies;* by Professor TYNDALL, F.R.S. (Proc. Roy. Inst. of Great Britain, vol. ii, p. 159).—The notion of an attractive force, which draws bodies towards the centre of the earth, was entertained by Anaxagoras and his pupils, by Democritus, Pythagoras, and Epicurus; and the conjectures of these ancients were renewed by Galileo, Huyghens, and others, who stated that bodies attract each other as a magnet attracts iron. Kepler applied the notion to bodies beyond the surface of the earth, and affirmed the extension of this force to the most distant stars. Thus it would appear, that in the attraction of iron by a magnet originated the conception of the force of gravitation. Nevertheless, if we look closely at the matter, it will be seen that the magnetic force possesses characters strikingly distinct from those of the force which holds the universe together. The theory of gravitation is, that every particle of matter attracts every other particle; in magnetism also we have the phenomenon of attraction, but we have also, at the same time, the fact of repulsion, and the final effect is always due to the difference of these two forces. A body may be intensely acted on by a magnet, and still no motion of translation will follow, if the repulsion be equal to the attraction. A dipping needle was exhibited: previous to magnetization, the needle, when its centre of gravity was supported, stood accurately level; but, after magnetization, one end of it was pulled towards the north pole of the earth. The needle, however, being suspended from the arm of a fine balance, it was shown that its *weight* was unaltered by its magnetization. In like manner, when the needle was permitted to float upon a liquid, and thus to follow the attraction of the north magnetic pole of the earth, there was

no motion of the mass towards the pole referred to; and the reason was known to be, that although the marked end of the needle was *attracted* by the north pole, the unmarked end was *repelled* by an equal quantity, and these two equal and opposite forces neutralized each other as regards the production of a motion of translation. When the pole of an ordinary magnet was brought to act upon the swimming needle, the latter was attracted,—the reason being that the attracted end of the needle being much nearer to the pole of the magnet than the repelled end, the force of attraction was the more powerful of the two; but in the case of the earth, the pole being so distant, the length of the needle was practically zero. In like manner, when a piece of iron is presented to a magnet, the nearer parts are attracted, while the more distant parts are repelled; and because the attracted portions are nearer to the magnet than the repelled ones, we have a balance in favor of attraction. Here then is the most wonderful characteristic of the magnetic force, which distinguishes it from that of gravitation. The latter is a simple unpolar force, while the former is duplex or polar. Were gravitation like magnetism, a stone would no more fall to the ground than a piece of iron towards the north magnetic pole: and thus, however rich in consequences the supposition of Kepler and others may have been, it was clear that a force like that of magnetism would not be able to transact the business of the universe.

The object of the evening's discourse was to inquire whether the force of diamagnetism, which manifested itself as a repulsion of certain bodies by the poles of a magnet, was to be ranged as a polar force, beside that of magnetism; or as an unpolar force, beside that of gravitation. When a cylinder of soft iron is placed within a helix, and surrounded by an electric current, the antithesis of its two ends, or in other words, its polar excitation, is at once manifested by its action upon a magnetic needle; and it may be asked why a cylinder of bismuth may not be substituted for the cylinder of iron, and its state similarly examined. The reason is, that the excitement of the bismuth is so feeble, that it would be quite masked by that of the helix in which it is enclosed; and the problem that now meets us is, so to excite a diamagnetic body that the pure action of the body upon a magnetic needle may be observed, unmixed with the action of the body used to excite the diamagnetic.

How this may be effected, was illustrated in the following manner:—an upright helix of covered copper wire was placed upon the table, and it was shown that the top of the helix attracted, while its bottom repelled, the same pole of a magnetic needle; its central point, on the contrary, was neutral, and exhibited neither attraction nor repulsion. This helix was caused to stand between the two poles N′ S′ of an astatic magnet; the two magnets S N′ and S′ N were united by a rigid cross piece at their centres, and suspended from the point *a*, so that both magnets swung in the same horizontal plane. It was so arranged that the poles N′ S′ were opposite to the central or neutral point of the helix, so that when a current was sent through the latter, the magnets were unaffected by the



current. Here then we had an excited helix which itself had no action upon the magnets, and we were thus at liberty to examine the action of a body placed within the helix and excited by it, undisturbed by the influence of the latter. The helix was twelve inches high, and a cylinder of soft iron six inches long suspended from a string and passing over a pulley could be raised or lowered within the helix. When it was so far sunk that its lower end rested upon the table, the upper end found itself between the poles N S, attracting one of them and repelling the other, and consequently deflecting the astatic system in a certain direction. When the cylinder was raised so that the upper end was at the level of the top of the helix, its lower end was between the poles N′ S′; and a deflection opposed in direction to the former one was the immediate consequence. To render these deflections more visible to the audience, a mirror *m*, was attached to the system of magnets; a beam of light thrown upon the mirror was reflected and projected as a bright disk against the wall of the theatre; the distance of this image from the mirror being considerable, and its angular motion double that of the latter, a very slight motion of the magnet was sufficient to produce a displacement of the image through several yards. This then is the principle of the beautiful apparatus* by which the investigation now brought forward was conducted. It is manifest that if a second helix be placed between the poles S N with a cylinder within it, the action upon the astatic magnet may be exalted. This was the arrangement made use of in the actual inquiry. Thus to intensify the feeble action, which it is here our object to seek, we have in the first place neutralized the action of the earth upon the magnets, by placing them astatically. Secondly, by making use of two cylinders, and permitting them to act simultaneously on the four poles of the magnets, we have rendered the deflecting force four times what it would be, supposing only a single pole to be used. Finally, the whole apparatus was enclosed in a suitable case, which protected the magnets from atmospheric currents, and the deflections were read off through a glass plate in the case, by means of a telescope and scale placed at a considerable distance from the instrument.

A pair of bismuth cylinders was first examined. Sending a current through the helices, and observing that the magnets swung perfectly free, it was first arranged that the cylinders within the helices had their central points opposite to the poles of the magnets. All being at rest the number on the scale marked by the cross wire of the telescope was 572. The cylinders were then moved so that two ends were brought to bear simultaneously upon the magnetic poles: the magnet moved promptly, and after some oscillations† came to rest at the number 612; thus moving from a smaller to a larger number. The other two ends of the bars were next brought to bear upon the magnet: a prompt deflection was the consequence, and the final position of equilibrium was 526; the movement being from a larger to a smaller number. We thus observe a manifest polar action of the bismuth cylinders upon the magnet; one pair of ends deflecting it in one direction, and the other pair deflecting it in the opposite direction.

* Devised by Prof. W. Weber, and constructed by M. Leyser, of Leipzig.

† To lessen these a copper damper was made use of.

Substituting for the cylinders of bismuth thin cylinders of iron, of magnetic slate, of sulphate of iron, carbonate of iron, protochlorid of iron, red ferrocyanid of potassium, and other magnetic bodies, it was found that when the position of the magnetic cylinders was the same as that of the cylinders of bismuth, the deflection produced by the former was always opposed in direction to that produced by the latter: and hence the disposition of the force in the diamagnetic body must have been precisely antithetical to its disposition in the magnetic ones.

But it will be urged, and indeed has been urged against this inference, that the deflection produced by the bismuth cylinders is purely due to the currents of induction excited in the mass by its motion within the helices. In reply to this objection, it may be stated, in the first place, that the deflection is permanent, and cannot therefore be due to induced currents, which are only of momentary duration. It has also been urged that such experiments ought to be made with other metals, and with better conductors than bismuth, for if due to currents of induction the better the conductor the more exalted will be the effect. This requirement was complied with.

Cylinders of antimony were substituted for those of bismuth. This metal is a better conductor of electricity, but less strongly diamagnetic than bismuth. If therefore the action referred to be due to induced currents we ought to have it greater in the case of antimony than with bismuth; but if it springs from a true diamagnetic polarity, the action of the bismuth ought to exceed that of the antimony. Experiment proves that the latter is the case, and that hence the deflection produced by these metals is due to their diamagnetic, and not to their conductive capacity. Copper cylinders were next examined: here we have a metal which conducts electricity fifty times better than bismuth, but its diamagnetic power is nearly null; if the effects be due to induction we ought to have them here in an enormously exaggerated degree, but no sensible deflection was produced by the two cylinders of copper.

It has also been proposed by the opponents of diamagnetic polarity to coat fragments of bismuth with some insulating substance, so as to render the formation of induced currents impossible, and to test the question with cylinders of these fragments. This requirement was also fulfilled. It is only necessary to reduce the bismuth to powder and expose it for a short time to the air to cause the particles to become so far oxydized as to render them perfectly insulating. The power of the powder in this respect was exhibited experimentally in the lecture; nevertheless, this powder, enclosed in glass tubes, exhibited an action scarcely less powerful than that of the massive cylinders.

But the most rigid proof, a proof admitted to be conclusive by those who have denied the antithesis of magnetism and diamagnetism, remains to be stated. Prisms of the same heavy glass as that with which the diamagnetic force was discovered, were substituted for the metallic cylinders, and their action upon the magnet was proved to be precisely the same in kind as that of the cylinders of bismuth. The inquiry was also extended to other insulators: to phosphorus, sulphur, nitre, calcareous spar, statuary marble, with the same invariable result: each of these substances was proved polar, the disposition of the force being the same as

that of bismuth and the reverse of that of iron. When a bar of iron is set erect, its lower end is known to be a north pole, and its upper end a south pole, in virtue of the earth's induction. A marble statue, on the contrary, has its feet a south pole, and its head a north pole, and there is no doubt that the same remark applies to its living archetype; each man walking over the earth's surface is a true diamagnet, with its poles the reverse of those of a mass of magnetic matter of the same shape and in a similar position.

An experiment of practical value, as affording a ready estimate of the different conductive powers of two metals for electricity, was exhibited, for the purpose of proving experimentally some of the assertions made by the speaker in reference to this subject. A cube of bismuth was taken and suspended by a twisted string between the two poles of an electro-magnet. The cube was attached by a short copper wire to a little square pyramid, the base of which was horizontal, and its sides formed of four small triangular pieces of looking-glass. A beam of light was suffered to fall upon this reflector, and as the reflector followed the motion of the cube the images cast from its sides followed each other in succession, each describing a circle of about thirty feet in diameter. As the velocity of rotation augmented, these images blended into a continuous ring of light. At a particular instant the electro-magnet was excited, currents were evolved in the rotating cube, and the strength of these currents, which increases with the conductivity of the cube for electricity, was practically estimated by the time required to bring the cube and its associated mirrors to a state of rest. With bismuth this time amounted to a score of seconds or more: a cube of copper, on the contrary, was struck almost instantly motionless when the circuit was established.

5. *On M. Petitjean's process for Silvering Glass;* by Professor FARADAY, D.C.L., F.R.S. (Proc. Roy. Inst. of Great Britain, vol. ii, p. 308).—M. Petitjean's process consists essentially in the preparation of a solution containing oxyd of silver, ammonia, nitric and tartaric acids, able to deposit metallic silver either at common or somewhat elevated temperatures; and in the right application of this solution to glass, either in the form of plates or vessels. 1540 grains of nitrate of silver being treated with 955 grains of strong solution of ammonia, and afterwards with 7700 grains of water, yields a solution, to which when clear 170 grains of tartaric acid dissolved in 680 grains of water are to be added, and then 152 cubic inches more of water, with good agitation. When the liquid has settled, the clear part is to be poured off; 152 cubic inches of water to be added to the remaining solid matter, that as much may be dissolved as possible; and the clear fluids to be put together aud increased by the further addition of 61 cubic inches of water. This is the silvering solution No. 1. A second fluid, No. 2, is to be prepared in like manner, with this difference, that the tartaric acid is to be doubled in quantity. The apparatus employed for the silvering of glass plate consists of a cast-iron table box, containing water within, and a set of gas burners beneath to heat it: the upper surface of the table is planed and set truly horizontal by a level, and covered by a varnished cloth: heat is applied until the temperature is 140° Fah. The glass is well cleaned, first with a cloth; after which a plug of cotton, dipped in the silvering fluid and a little polishing powder,

is carefully passed over the surface to be silvered, and when this application is dry it is removed by another plug of cotton, and the plate obtained perfectly clean. The glass is then laid on the table, a portion of the silvering fluid poured on to the surface, and this spread carefully over every part by a cylinder of india-rubber stretched upon wood which has previously been cleaned and wetted with the solution; in this manner a perfect wetting of the surface is obtained, and all air bubbles, &c. are removed. Then more fluid is poured on the glass until it is covered with a layer about the $\frac{1}{10}$th of an inch in depth, which easily stands upon it; and in that state its temperature is allowed to rise. In about ten minutes or more, silver begins to deposit on the glass, and in fifteen or twenty minutes a uniform opaque coat, having a greyish tint on the upper surface, is deposited. After a certain time the glass employed in the illustration was pushed to the edge of the table, was tilted that the fluid might be poured off, was washed with water, and then was examined. The under surface presented a perfectly brilliant metallic plate of high reflective power, as high as any that silver can attain to; and the coat of silver, though thin, was so strong as to sustain handling, and so firm as to bear polishing on the back to any degree, by rubbing with the hand and polishing powder. The usual course in practice, however, is, when the first stratum of fluid is exhausted, to remove it, and apply a layer of No. 2 solution; and when that has been removed and the glass washed and dried, to cover the back surface with a protective coat of black varnish. When the form of the glass varies, simple expedients are employed; and by their means either concave or convex, or corrugated surfaces are silvered, and bottles and vases are coated internally. It is easy to mend an injury in the silvering of a plate, and two or three cases of repair were performed on the table.

The proposed advantages of the process are,—the production of a perfect reflecting surface; the ability to repair; the mercantile economy of the process (the silver in a square yard of surface is worth 1*s.* 8*d.*); the certainty, simplicity, and quickness of the operation; and, above all, the dismissal of the use of mercury. In theory the principles of the process justify the expectations, and in practice nothing as yet has occurred which is counter to them.

6. *Some observations on divided gold;* by Prof. Faraday, D.C.L., F.R.S. (ib., p. 310).—With regard to the second part of the evening's discourse, the speaker said he had been led by certain considerations to seek experimentally for some effect on the rays of light, by bodies which when in small quantities had strong peculiar action upon it, and which also could be divided into plates and particles so thin and minute as to come far within the dimensions of an undulation of light, whilst they still retained more or less of the power they had in mass; and though he had as yet obtained but little new information, he considered it his duty, in some degree, to report progress to the members of the Royal Institution. The vibrations of light are, for the violet ray 59,570 in an inch, and for the red ray 37,640 in an inch; it is the lateral portion of the vibration of the ether* which is by hypothesis suppossed to affect the

* Analogous transverse vibration may easily be obtained on the surface of water or other fluids, by the process described in the Philosophical Transactions for 1831 p. 336, &c.

eye, but the relation of number remains the same. Now a leaf of gold as supplied by the mechanician is only $\frac{1}{280,000}$ of an inch in thickness, so that seven and a half of these leaves might be placed in the space occupied by a single undulation of the red ray, and five in the space occupied by a violet undulation. Gold of this thickness and in this state is transparent, transmitting green light, whilst yellow light is reflected; there is every reason to believe also that some is absorbed, as happens with all ordinary bodies. When gold leaf is laid upon a layer of water on glass, the water may easily be removed, and solutions be substituted for it; in this way a solution of chlorine, or of cyanid of potassium, may be employed to thin the film of gold; and as the latter dissolves the other metals present in the gold (silver, for instance, which chlorine leaves as a chlorid), it gives a pure result; and by washing away the cyanid, and draining and drying the last remains of water, the film is left attached to the glass: it may be experimented with, though in a state of extreme tenuity. Examined either by the electric lamp, or the solar spectrum, or the microscope, this film was apparently continuous in many parts where its thickness could not be a tenth or twentieth part of the original gold leaf. In these parts gold appeared as a very transparent thing, reflecting yellow light and transmitting green and other rays; it was so thin that it probably did not occupy more than a hundredth part of a vibration of light, and yet there was no peculiar effect produced. The rays of the spectrum were in succession sent through it; a part of all of them was either stopped or turned back, but that which passed through was *unchanged* in its character, whether the gold plate was under ordinary circumstances, or in a very intense magnetic field of force.

When a solution of gold is placed in an atmosphere containing phosphorus vapor the gold is reduced, forming films that may be washed and placed on glass without destroying their state or condition: these vary from extreme thinness to the thickness of gold leaf or more, and have various degrees of reflective and transmissive power; they are of great variety of color, from grey to green, but they are like the gold leaves in that they do not change the rays of light.

When gold wires are deflagrated by the Leyden discharge upon glass plates, extreme division into particles is effected, and deposits are produced, appearing, by transmitted light, of many varieties of color, amongst which are ruby, violet, purple, green, and grey tints. By heat many of these are changed so as to transmit chiefly ruby tints, retaining always the reflective character of gold. None of them affect any particular ray selected from the solar spectrum, so as to change its character, otherwise than by reflection and absorption; what is transmitted still remains the same ray. When gold leaf is heated on glass the heat causes its retraction and running together. To common observation the gold leaf disappears, and but little light is then reflected or stopped: but if pressure by a polished agate convex surface be applied to the gold in such places, reflective power reappears to a greater or smaller degree, and green light is again transmitted. When the gold films by phosphorus have been properly heated, pressure has the same effect with them.

If a piece of clean phosphorus be placed *beneath* a weak gold solution, and especially if the phosphorus be a clear thick film, obtained by the

evaporation of a solution of that substance in sulphid of carbon, in the course of a few hours the solution becomes colored of a ruby tint; and the effect goes on increasing, sometimes for two or three days. At times the liquid appears clear, at other times turbid. As far as Mr. Faraday has proceeded, he believes this fluid to be a mixture of a colorless transparent liquid, with fine particles of gold. By transmitted light, it is of a fine ruby tint; by reflected light, it has more or less of a brown yellow color. That it is merely a diffusion of fine particles is shown by two results; the first is, that the fluid being left long enough the particles settle to the bottom: the second is, that whilst it is colored or turbid, if a cone of the sun's rays (or that from a lamp or candle in a dark room) be thrown across the fluid by a lens, the particles are illuminated, reflect yellow light, and become visible, not as independent particles, but as a cloud. Sometimes a liquid which has deposited much of its gold, remains of a faint ruby tint, and to the ordinary observation, transparent; but when illuminated by a cone of rays the suspended particles show their presence by the opalescence, which is the result of their united action. The settling particles, if in a flask, appear at the bottom, like a lens of deep colored fluid, opaque at the middle, but deep ruby at the edges; when agitated they may be again diffused through the liquid. These particles tend to aggregate into larger particles, and produce other effects of color. It is found that boiling gives a certain degree of permanence to the ruby state. Many saline and other substances affect this ruby fluid: thus, a few drops of solution of common salt being added, the whole gradually becomes of a violet color; still the particles are only in suspension, and when illuminated by a lens are a golden yellow by reflected light: they separate now much more rapidly and perfectly by deposition from the fluid than before. Some specimens, however, of the fluid, of a weak purple or violet color, remain for months without any appearance of settling, so that the particles must be exceedingly divided; still the rays of the sun or even of a candle in a dark room, when collected by a lens, will manifest their presence. The highest powers of the microscope have not as yet rendered visible either the ruby or the violet particles in any of these fluids.

Glass is occasionally colored of a ruby tint by gold; such glass, when examined by a ray of light and a lens, gives the opalescent effect described above, which indicates the existence of separate particles; at least such has been the case with all the specimens Mr. Faraday has examined. It becomes a question whether the constitution of the glass and the ruby fluids described is not, as regards color, alike. At present, he believes they are; but whether the gold is in the state of pure metal, or of a compound, he has yet to decide. It would be a point of considerable optical importance if they should prove to be metallic gold; from the effects presented when gold wires are deflagrated by the Leyden discharge over glass, quartz, mica, and vellum, and the deposits subjected to heat, pressure, &c., he inclines to believe they are pure metal.

## II. MINERALOGY AND GEOLOGY.

1. *On the probable origin of some Magnesian Rocks;* by T. STERRY HUNT, (in a letter to one of the Editors.)—It is well known that certain mineral waters when exposed to the air deposit large quantities of carbonate of lime, and that the beds of travertine thus produced at the present day, often form extensive rock masses. We cannot doubt that some ancient limestones have had a similar origin, and among these, portions of the *sparry limestones* of Eaton in the Hudson River group, which sometimes exhibit the agatized structure and texture of alabaster. The various deposits of carbonate of lime thus formed, often contain iron as oxyd or as carbonate, besides a great variety of other elements including many of the metals, but magnesia is always wanting in them, or present only in traces. Berzelius remarked in his analysis of the waters and the travertine of the Carlsbad springs, that the large portion of carbonate of magnesia which the water contains, remains dissolved after the precipitation of the lime, and is only separated by evaporation. The precipitate produced in a solution of a magnesian salt by the addition of carbonate of soda is redissolved by an excess of the magnesian or the alkaline salt, but the evaporation of the liquid deposits the magnesian carbonate in a granular form.

In my investigations of mineral springs of the Lower Silurian Rocks of Canada, I have found certain waters containing common salt with large amounts of chlorid of calcium and magnesium, but destitute of carbonates; there are other saline waters, which, with less of earthy chlorids, give by evaporation large amounts of earthy carbonates, in which the magnesia prevails, sometimes almost to the exclusion of lime. These springs apparently owe their origin to the admixture of waters of the first-mentioned class with those of the alkaline springs, so common in the same region, and in which carbonate of soda predominates. By the careful addition of carbonate of soda to such a water, nearly the whole of the lime may be precipitated while a great part of the magnesia remains in solution. The spontaneous evaporation of such magnesian waters arising from the action of carbonate of soda upon sea-water or that of the springs above mentioned, would give rise to beds of magnesian carbonate, either pure or mingled with carbonate of lime.

Such deposits occur in Canada, in the form of thin layers, interrupted beds, or lenticular masses, interstratified with pure limestones, which sometimes appear to be travertines, and at others perhaps ordinary sedimentary limestones, holding orthoceratites, trilobites and other fossils of the Hudson River group. The magnesian beds are always granular, destitute of fossils, and generally mixed with sand or clay; they often pass into a veritable conglomerate, holding fragments of quartz or limestone. The carbonate is sometimes a dolomite, and at others a magnesite, destitute of lime, but a portion of carbonate of iron is never wanting. The pure carbonate of lime also, but more rarely, serve as the cement to quartzose sand or limestone pebbles, and the whole of these rocks are interstratified with the sandstones and shales, often graptolitic, which make up the great mass of the Quebec division of the above mentioned group.

I have already in a previous note indicated the manner in which I suppose these silicious and argillaceous magnesites and dolomites to have been in certain parts of the formation transformed by the intervention of solutions of alkaline carbonates into silicates, such as talc, serpentine, chlorite, pyroxenite, etc. A farther development of my views of the metamorphism of sediments, with the results of the investigation of a great many altered rocks will appear in the Report of Progress of the Geological Survey of Canada for the last three years—now in press.

Montreal, July 6th, 1857.

2. *Chlorids.*—At the recent eruption of Vesuvius (in 1855) Deville made some observations on the material issuing from fumaroles over the cooling lava, and found that there was no vapor of water, and that the chlorids of sodium and potassium predominated, while there were sulphates in small quantities, no fluorids, and perhaps some carbonic acid. The uncondensable gases he has not yet satisfactorily examined. Higher above where the heat is less, the smell of sulphurous acid was perceived, but the fumaroles still gave out almost exclusively chlorid gases. In places where the vapor of water was given out, as in the upper crater, sulphurous acid was more abundant and the odor of sulphuretted hydrogen was perceptible with perhaps vapor of sulphur; from a fumarole a considerable amount of water was condensed, upon which small crystals of sulphur floated. It appears therefore, that at the points of maximum intensity in an eruption, chlorids are given out without water; but in the places where the action is of the ordinary kind about the summit, sulphur and vapor of water are abundant.

3. *Agalmatolite;* by Dr. C. T. Jackson, (Proc. Bost. Soc. Nat. Hist., vi, 52.)—To this mineral is referred a rock with a soapy feel from the borders of the Deep River coal field, North Carolina. It afforded Dr. Jackson on analysis, $\ddot{S}i$ 75·00, $\ddot{A}l$ 18·75, $\dot{K}$ 2·00, $\dot{H}$ 3·50 = 99·25 with traces only of oxyd of iron. It is ground up and sold in New York at $40 a ton, making a delicate white substance satin-like in feel similar to China clay. It is supposed to be used in adulterating white lead and also fancy soaps, and for glazing or satinizing wall-paper.

4. *Corundum.*—Artificial crystals of sapphire have recently been obtained by using an ordinary crucible in a forge, by A. Gaudin (L'Institut, No. 1214). He mixed, in the crucible, lampblack, ammonia or potash alum previously calcined with an equal weight of sulphate of potash, and subjected the whole to a high heat for 15 minutes. He thus obtained the alumina crystallized without discoloration from a trace of iron or any other metal. The sulphuret of potassium produced through the reaction is regarded as an energetic solvent of the alumina, and from it the crystallization takes place, either through its evaporation or greater concentration.

5. *Slate rock of Hungary.*—A slate resembling talcose slate, from the Gabbro or Zipser in Hungary, and also much like the Sericite slate of Taurus contains, according to C. F. Chandler, (Inaug. Dissert.):

| $\ddot{S}i$ | $\ddot{A}l$ | $\ddot{F}e$ | $\dot{M}g$ | $\dot{N}a$ | $\dot{K}$ | $\dot{H}$ |
|---|---|---|---|---|---|---|
| 75·28 | 13·43 | 1·88 | 1·79 | 0·37 | 4·54 | 2·49=99·78. |

Specific gravity 2·659.

6. *Notes on the Bermuda Islands;* by ANDREW SCOTT.—The group of Bermuda Islands is situated in the middle of the Atlantic, just on the border of the tropics, partaking of their fruitful climate without their heat and insalubrity, and of the north without its cold winters. It consists of three or four principal islands and several hundred smaller ones, enclosing picturesque bodies of deep and shallow water, and is nearly surrounded by reefs almost level with the sea, extending seven to ten miles from the shores; its greatest length from northeast to southwest is about eighteen miles. The islands are all composed of coral like the formation of the Bahamas and Florida reefs, but differ from them in that they are much more elevated, some of the hills being a hundred feet above the sea level. The soil is very scanty and supports naturally a stunted growth of red cedar, and when cultivated produces rich crops.

A process of nature is now going on in one of the principal islands, which, in connection with other facts may serve to show how they have been raised to their present height without supposing a convulsion or volcanic action.

The southern shores are bold; a heavy surf is constantly breaking in, converting the coral as fast as it forms into sand, and forming extensive beaches. The southwest winter gales at times are dreadfully severe; the wind has taken up this sand and drifted it in one place half a mile or more over the summit of the island, which is near one hundred feet high; it now covers land forty or fifty feet deep which but a few years ago was cultivated. This body of sand is in view from the town of Hamilton; it is fast increasing, and gives some anxiety to its inhabitants for fear that it may encroach upon their harbor.

Now the whole formation of the islands above the level of the sea is composed of just such sand, which, wherever it is exposed to salt water, in a short time becomes hard. The surface rocks on the seashore are very hard and rough, consisting for the most part of broken shells and corals cemented together by the action of (probably) the lime in the salt water. In the higher rocks there are no fossils; the few shells found are similar to living ones, and may have been carried up by birds; below the surface the rock quarries out as soft as chalk, and when used for building it becomes hard by saturating with lime-water. In the quarries and excavations for fortifications and roads, the formation is clearly exposed; it is all one kind, varying in hardness from loose sand to close-grained limestone, lying in irregular beds just as sand might be supposed to have drifted, and in some places showing a stratum or bed of soil identical with the present soil containing roots of the cedar and vegetable remains but no signs of ever having been under water. There are no marks of volcanic agency anywhere. There are several caverns and fissures near the shores, all with more or less of sea water in them, and so situated that they might have been hollowed out by the action of wind and water without any other extraordinary cause. Stalactites are found in these caverns. The water in wells does not rise above the level of the sea and is too brackish for use; the inhabitants depend upon rains.

The facts here stated of the geological formation of the Islands of Bermuda serve only to confirm the received theory of the formation of coral islands, and may not be new; but on account of their elevation and apparent stratification, some of the best informed gentlemen of Bermuda take a different view and ascribe it to an upheaving force.

7. *Note on the Cherokine of C. U. Shepard;* by T. Sterry Hunt. (From a letter to one of the editors, dated Quebec, June 23, 1857.)*—The specimen of cherokine was in small imperfect milk-white prisms forming a little layer on a fragment of a granular sulphuret of lead, copper, etc. (I did not carefully note them). The whole amount is not more than six or eight grains, so that I could not well determine its density. I took about half of it and found it to consist of *lead* with *phosphoric acid*, besides traces, too small to be estimated, of a whitish precipitate by ammonia in the filtrate from the PbS—it might be phosphate of lime, or possibly alumina, but was probably not one per cent of the mineral, which is a *pure pyromorphite.* Damour, however, found in some pyromorphites from Brittany variable amounts of hydrated alumina, up to sixteen per cent, constituting a passage into plumbo-resinite. I have from him a specimen of *crystalline aluminous pyromorphite*, which is associated with a pure phosphate, and Shepard may have analyzed something of the kind, although my crystals of cherokine are pure phosphate of lead.

8. *Notice of the Occurrence of Aragonite near the Arkansas River;* by W. J. Taylor.—It will be of interest to mineralogists to learn of the occurrence of aragonite, sixteen miles from the crossing of the Arkansas River on the north boundary of the Creek nation. It is found there in six-sided prisms with gypsum, imbedded in a ferruginous clay. The appearance of the crystals, together with the associated minerals, renders it impossible to distinguish some of the specimens of this locality, from some of those from Molina and Valencia, in Aragon, Spain. Dr. S. W. Woodhouse first brought specimens from this locality in 1850, and presented them to the Academy of Natural Sciences of Philadelphia. I am indebted to him for a specimen and for the facts relating to its occurrence. It is found in hills of considerable heights, which rise suddenly from the level surface of the prairie. The crystals obtained have a diameter of about three-eighths of an inch, but they were taken hastily from the cliffs without the means or the time necessary for making good selections.

9. *Descriptions of New Species of Fossils from the Cretaceous Formations of Nebraska, with observations upon Baculites ovatus and B. compressus, and the Progressive Development of the Septa in Baculites, Ammonites and Scaphites;* by James Hall and F. B. Meek. Communicated to the American Academy, June 27, 1844, and published in its Transactions, volume v, p. 380, 1855.—This important paper by Messrs. Hall and Meek, written three years since, though printed later, by some oversight has not been noticed in this Journal. The authors state in the first paragraph that the collections were made by Messrs. F. B. Meek and F. V. Hayden, and we understand that the excursion to the Nebraska regions was projected by Professor Hall and carried out at his expense. The paper contains descriptions of one crustacean and thirty-three new molluscan fossil species of the Nebraskan Cretaceous beds, and is illustrated by seven lithographic plates in 4to. It presents a comparison of the fossils with those of New Jersey, and alludes to the distinction between them and those of Texas. As this subject and that of the subdivisions of the beds are considered in detail in Professor Hall's

* The specimen of cherokine in Professor Hunt's hands was sent him by Professor Shepard, and the examination here mentioned was made at the request of J. D. Dana.—Eds.

article in this volume, p. 72, it is unnecessary here to recur to it again. The changes which age makes in the septa of species of Baculites is well exhibited. In the young the septa were found to be extremely simple, small undulations existing in place of the deep lobes and plications. The same is true of species of Scaphites and Ammonites, and a corresponding difference is apparent between the interior (or primal) and outer whorls of the shells. The paper observes that the fact, though not new with reference to the Ammonites, is for the first time announced with respect to the other two genera.

10. *Descriptions of new species of Fossils from the Carboniferous Limestones of Indiana and Illinois;* by JAMES HALL, (Trans. Albany Institute, vol. iv, pp. 1 to 37.)—This paper by Professor Hall contains descriptions of a large number of Carboniferous fossils, mostly molluscan. It includes of Pentremites, 2 species; Terebratula, 3; Spirifera, 2; Spirigera, 1; Retzia, 1; Rhynconella, 6; Orthis, 2; Productus, 2; Conocardium, 6; Nucula, 2; Cypricardella (n. gen.), 4; Cypricardia, 2; Euomphalus, 4; Pleurotomaria, 12; Murchisonia, 5; Loxonema, 2; Bulimella (n. gen.), 3; Holopea, 1; Natica, 2; Capulus, 1; Bellerophon, 2; Conularia, 1; Nautilus, 1; Orthoceras, 1; Cythere (Crustacean), 1; Spirorbis, 2; Rotalia, 1. These species are from the subcarboniferous limestone, and many of them from Spergen Hill and Bloomington, Indiana. The particular stratum is called the Second Archimedes or Warsaw limestone, lying above the Keokuk or lower Archimedes limestone. Professor Hall describes also one Terebratula from the coal measures, (*T. millepunctata*) which occurs at Topeka in Kansas, and also at Pecos village on the line of the Pacific Railroad surveyed by Lieut. Whipple.

11. *On the Cretaceous Fossils of Vancouver's Island, Western America,* by F. B. MEEK, (Trans. Albany Institute, vol. iv, p. 37.)—The fossils described by Mr. Meek were placed in his hands by Dr. J. S. Newberry, Geologist of Lieut. Williamson's North California and Oregon Exploring Expedition. The fossils noticed or described are *Cardium scitulum, Arca Vancouverensis, Nucula Traskana, Dentalium Nanaimoensis, Baculites ovatus* Say, *Ammonites* (Scaphites?) *ramosus, A. Newberryanus,* with fragments of Inoceramus, Bulla, Rostellaria; and from another rock of probably related age, *Pholadomya* (*Goniomya*) *borealis, P. subelongata, Thracia? occidentalis,* and *subtruncata, Arca* (*Cucullæa*) *equilateralis,* and *Trigonia Evansana.* The evidence is not positive that the fossils may not be older than the Cretaceous, though probably of that formation.

12. *Notes explanatory of a Map and Section illustrating the Geological Structure of the country bordering on the Missouri River, from the mouth of the Platte River to Fort Benton;* by Dr. F. V. HAYDEN, (Proc. Acad. Nat. Sci. Philadelphia, May, 1815.)—The mouth of the Platte is about in lat. 41° and long. 96°, and Fort Benton at lat. 47½° and long. 110½°, so that Fort Benton is far north and west of the starting point, owing to the great curve of the Missouri to the west along lat. 47 and 48°. The map is derived from the most reliable records in the War Department, as is also the profile section for so many hundred miles. Attractive as have been the fossil developments in this territory, the country has been a terra incognita except to explorers. Now, however, we can begin to trace out the positions of the geological formations. We find the Carboniferous series in the northeast part of Kansas and southeast of Nebraska, passing under the Cretaceous on the west and also on the north near the mouth

of Platte River. Thence north over a wide extent the Cretaceous is spread out, dipping westward under the Tertiary of the Bad Lands of White River in lat. 43 to 44° perhaps, and terminated still farther north and west by the great Lignite Tertiary basin some hundred miles in extent, till above lat. 47° and long. 108 to 110° appears again the Cretaceous formation. Five vertical sections of the Cretaceous are given, No. 1 being found on the southeast at Platte River, and again on the northwest part of the long section at Fort Benton. The author of this paper, Dr. Hayden, has spent no small part of four years in the territory and has more fully explored its natural history than any other individual. This and the following paper are the results of explorations under the War Department. C. D.

13. *Descriptions of New Species and Genera of Fossils collected by Dr. F. V. Hayden in Nebraska Territory in* 1856, (Ibid.)—The new species described in this paper are about forty, under seventeen genera, of which two are new. Preceding these descriptions are important "Remarks on the Tertiary and Cretaceous Formations," filling nineteen pages and presenting full confirmation of the "parallelism" of these rocks with others over the country. Several sections of rocks, widely separated, are given for comparison, which with the fossils establish the "parallelism" announced in a preceding paper. An abstract would be too long for this place. The facts also tend to prove that the Tertiary of White River, that "Cemetery of Pre-Adamite Mammals," is Miocene, as first suggested by Dr. Leidy. For other interesting geological conclusions reference must be made to the paper itself, the joint labor of F. B. Meek and F. V. Hayden, M.D.

The scientific world is under much obligation to the War Department for these and other discoveries in the territories of the United States. Dr. Hayden was in 1856 with the party commanded by Lieut. G. K. Warren, U. S. Topographical Engineer, in Nebraska, and no partial credit is due to this officer for his interest and aid in the prosecution of geological discoveries. In advance of the final report of Lieut. Warren, this paper is permitted by the Hon. Secretary of War to be made public through the Academy of Sciences. C. D.

14. *North Carolina Mountains.*—The lofty peaks of western North Carolina were barometrically measured by Prof. Guyot, in July, 1856, with the following results. These twelve summits are all higher than Mount Washington in New Hampshire, which according to Professor Bache's survey is 6285 feet in height.

| Name. | Height. |
|---|---|
| 1. Clingman's Peak, | 6701 feet. |
| 2. Guyot's Peak (or Balsam Cone), | 6661 " |
| 3. Sandoz Knob, | 6612 " |
| 4. Hairy Bear, | 6597 " |
| 5. Cat-tail Peak, | 6595 " |
| 6. Gibbes' Peak, | 6586 " |
| 7. Mitchell's Peak, | 6576 " |
| 8. Sugar-Loaf (or Hallback Peak), | 6401 " |
| 9. Potatoe Top, | 6389 " |
| 10. Black Knob, | 6377 " |
| 11. Bowler's Pyramid, | 6345 " |
| 12. Roan Mountain, | 6318 " |

15. *Himalayas.*—According to recent surveys of the Himalaya mountains by Colonel Waugh, there is a loftier peak than the one that has long stood first in the books.

Dhualagiri, *Mount Everest* (the new peak), Kintschindjunga, and Tschumalari stand nearly in a line,—Dhualagiri being the westernmost, —between the meridians 83° 32′ and 89° 19′ east of Greenwich, and the parallels 28° 42′ and 27° 42′. The heights of the four are as follows:

| | | |
|---|---|---|
| Dhualagiri (lat. 28° 42′, long. 83° 32′), | - | 26,826 |
| Mt. Everest (lat. 27° 59′, long. 85° 58′), | - | 29,002 |
| Kintschindjunga (lat. 27° 42′, long. 88° 11′), | | 28,156 |
| Tschumalari (lat. 27° 50′, long. 89° 19′), | - | 23,946 |

*Petermann's Mitth. Geog.*, 1856, p. 379.

16. *Notes and Queries on the Drying up of the Yellow River, China;* by D. J. Macgowan, M. D.—We are accustomed to attach more importance to records of physical phenomena contained in the annals of China than most students of Chinese; yet we have never been able to give full credence to accounts of the temporary drying up of large rivers. The recent disappearance however, of a great part of the Hwang (Yellow river), must be regarded as explanatory, if not confirmatory of these fluviatile vicissitudes.

From beyond Süchau to its embouchure a distance of more than 200 miles, the Yellow River has been dry for several years!

On referring to records of similar phenomena we find the following:

In the year 1766 B. C. the I and Loh (tributaries of the Hwang) became dry. At or about the same time the Tai mountain, 200 miles distant in Shantung fell: a seven years drought occurred soon after.

About the year 1154 the Hwang, or Yellow River itself became dry.

In 778 B. C. an earthquake affected the basins of the King Loh and Wei (affluents of the Hwang) when these rivers dried up. The fall of a mountain, or a landslip also accompanied this convulsion.

In the year 310 of our era, the Yellow River was fordable at Honan, as were also the Loh and adjacent streams.

At the close of the Sung dynasty 1278 A. D. the Tsientang was so nearly dry at Hangchau as to be fordable. The opportunity it presented of crossing was embraced by the Mongols who were in pursuit of the last of the Sung emperors. The absence of tides for three days is assigned as the cause of this remarkable state of that river: an explanation which is obviously insufficient, even though the tidal wave had failed to rise.

Further research would probably extend this list. In history, these records are distinguished from those that relate to the shifting of channels, overflowing of banks, and other obstructions to which rivers are subjected.

We come now to our own days.

In the latter part of 1852 the people of Hwaingan found the river fordable: in the spring of the ensuing year travellers crossed it dry shod, since which time it has been, to use the Chinese term applied to it, "as dry as dust." We have in our employ the former Secretary of the Commissioner of the Grand Canal, who resided in Hwaingan from February to September, 1853. Nearly the whole of the following year he spent farther up the river at Süchau. The dryness of the channel at the former place attracted his attention, but he found prevailing such a superstitious

dread of the subject that people avoided conversing about it: it was believed that even politics might be discussed with less danger, the fear being, that if not let alone altogether, the dangerous stream might reappear, and with greater power. At Süchau, says our informant, a few puddles might be seen, and a rivulet which a child could ford. From various sources we learn that as high up as Kaifung there is so little water that boats can no longer approach the city. The subject is seldom referred to in the *Gazette*. In May last, the Commissioner having charge of the lower portion of the Hwang reported, that out of the twenty-two *ting* under his jurisdiction nine were entirely dry. Last May the emperor, in a sentential document, enumerating the calamitous occurrences of his short reign says, "*the* river does not flow as hitherto," evidently regarding that as an evil omen. A careful search of the *Gazette* of the past four years would perhaps throw more light on the subject; the above is all that we have noted.

It will be remembered that an earthquake was felt in the maritime portion of the Plain on the 16th December, 1852. Did the earthquake precede, was it synchronous with, or did it follow the fluviatile phenomenon?

In the following year earthquakes occurred over this same region April 15th, 24th and 25th. A newly formed part of the coast north of the Yangtz disappeared in one of those shocks. About the same time, for 15 successive days, destructive shocks were experienced in Kansuh. In 1854 several slight earthquakes were felt in the south of China and in the China sea; and in 1855 occurred the great earthquake at Simoda which as we have elsewhere stated in detail caused an elevation of the inland waters of the southeast corner of the Plain.

In the spring of the present year earthquakes were of frequent occurrence in Manchuria. In fine, the whole of southeast Asia, has within the past few years been disturbed by an extraordinary number of earthquakes. It is for dynamic geology, with which we are in no wise conversant, to inform us if there is any connection between these subterranean forces, and the change which has come over the Yellow River. Although no proper geodetical survey has been made, we know that a portion of the lower part of the Hwang is higher than the adjacent plain. A very slight elevation of that region of country would suffice to turn the waters into their ancient channels. We have indeed received verbal accounts from travellers to the effect that the stream now passes through the prefecture of Tsauchau in the southwest part of Shantung, and thence as of old, in what particular way is not stated, to the Gulf of Pechele. On the other hand the above named Secretary states that in his journey from Peking to Hwaingan made in February 1853 he found from Tientsing to that point on the canal where it receives the waters of the Yunho less water than usual, and from thence where the current turned in his favor the quantity of water in the canal became less and less until he reached its junction with the Yellow River where it also was dry. Moreover the waters were no where less pellucid than ordinary. From various other sources we have received similar accounts, which like this, palpably contradict the statements which represent the Hwang as having taken a northeast course. How could that vast sheet of water find its way into the Gulf without imparting its hue to the streams it invaded? Again how could the river find exit in the manner indicated without overflowing rivers the level of which in some places is above that

of the adjacent country, having dykes scarcely adequate to sustain their normal pressure? Yet no change is recorded in the condition of the streams entering into the Gulf of Pechele;—no floods;—it seems as if "Chinese sorrow" were assuaged by some wand unseen. There is confessedly much about that river which we do not know. We do know however that in bye-gone centuries it was a sad vagrant, and that ever since the palmy days of the Patriarchal emperor Yu, (the first, if not the greatest of civil engineers) it has been an unconscionable spendthrift. No good therefore could be expected to come of it; yet for it to terminate so mysteriously that to find its end, one is obliged to rush into print, is what we never expected. Has the earth opened and swallowed up this trouble of China, that is to say, did the earthquake which appears to have elevated the seaward part of its bed, leave parallel chasms into which the waters descended through the alluvial bottom? If so, what was thence their course?—*North China Herald.*

Ningpo, November 1st, 1856.

17. *A Sketch of the Geology of Tennessee*, embracing a description of its minerals and ores, their variety and quality, modes of assaying and value, with a description of its soils and productions and palæontology; by Richard O. Currey, M.D., late Professor of Chemistry and Geology in the East Tennessee University. 128 pp., 8vo, with a map.—This small work gives a brief description of the rocks of the State, and contains a large engraved geological map from the report of Professor Safford, the State Geologist, noticed in a former volume of this Journal. The pages were written as a popular account of the mineral resources of the State, and first published to a considerable extent in the newspapers and a medical journal of Tennessee. The material has been rearranged in the preparation of the volume. The author often accompanied Dr. Troost in his excursions and dedicates his work to this distinguished geologist. In 1854 he published a geological map of the State, and he announces in his preface that he is engaged on a general work entitled "The Geology of the Southern States."

18. *Devonian Trees.—Fossil wood* is announced by J. W. Dawson (Proceedings Amer. Assoc., 10th meeting, p. 174) as occurring in the Devonian sandstones of Gaspé. The wood was black and silicified, being a trunk four feet long, and seven to nine and a half inches in diameter. A cross section exhibited a distinct cellular tissue, with circular, not crowded, cells; and there were well-defined rings of growth, averaging about a line in breadth. In a vertical section, the cells were seen to be elongated and to terminate in conical points; they showed traces of transverse and diagonal fibres, sometimes decussating, but no medullary rays or disc structures were visible. The tree was referred to the Coniferæ, but stated to differ materially from any previously observed form. The author adds that it may be related to fossil trees of the Devonian "Cypridina schists" of Saalfield in Meiningen, described by Professor Unger as of very singular organization as if the prototypes of the "Gymnosperms."

19. *Crinoids.*—An important paper on the Devonian Crinoids from the vicinity of Coblentz on the Rhine, by F. Zeiler and Ph. Wirtgen, and illustrated by 12 plates is contained in the Verhandlungen des naturhistorischen Vereins, Bonn. 1855, p. 17 and 79.

## III. BOTANY AND ZOOLOGY.

1. *Journal of the Proceedings of the Linnæan Society*, Vol. I, No. 4, concluding the volume. 1857.—The Botanical portion contains thirteen articles, nearly all of them short ones. Mr. Berkeley contributes a note on the Recent Discoveries in relation to the microgonidia [or androspores] of Fresh-water Algæ, viz. those of Pringsheim in *Vaucheria* and *Œdogonium*, &c. The main object of the communication is to record the fact,—now that the interesting nature and function of these bodies have been demonstrated,—that Mr. Thwaites had observed and made sketches of them in *Œdogonium* more than ten years ago, and conjectured them to be antheridia.*

Mr. Currey describes a new *Peziza*, being the full development of *Sclerotium roseum*.

Mr. Bennett describes a new Leguminous genus, *Guibourtia*, the Kobo-tree of Sierra Leone, allied to *Copaifera*, and producing one of the kinds of Africal copal largely exported from that country to England; and Mr. Archer gives some account of this substance.

Dr. Seemann follows with a communication, On the Palm of Timbuctoo, and identifies it, through information supplied by Drs. Barth and Vogel, with the *Borassus? Æthiopum* of Von Martius.

Mr. Berkeley, adverting to the statement that a coarse kind of bread is said to be made in Siberia and Lapland from the rootstocks of *Pteris aquilina*, the common Brake, and to the well known fact that those of a probable variety of the same species, *P. esculenta*, furnished the New Zealanders with a large part of their food, undertook to prepare a sort of bread from the rootstocks of the English plant. After digesting the prepared pulp in water for twenty-four hours and washing away the abundant and ill-flavored slimy matter, it was kneaded into a cake and baked. "The result was a coarse but palatable food, perfectly free from any disagreeable flavor, much better,—and probably not less nutritious,—than Cassava bread."†

Mr. Berkeley next describes some Entomogenous *Sphæriæ*, premising that: "No country in the world seems to abound more in *Fungi* than the United States. I have something approaching to 5000 species in my herbarium from two or three of the Southern States alone; and it is quite certain, from the new forms which are constantly occurring, that the number is far from being exhausted." Those here described are five new species of *Cordyceps* (collected by Mr. Ravenel and Dr. Curtis), all probably growing out of larvæ of different insects. They are all figured on an accompanying plate.

Mr. Masters describes a monstrosity of *Saponaria officinalis*, in which the (usually bifid) crown or scale of the petals was transformed, more or

* An abstract of the results reached by Pringsheim, and also by Cohn, &c. &c.—in their recent most interesting contributions to our knowledge of reproduction in the lower Cryptogamia,—demonstrating true sexual reproduction in these simple plants,—will be given in an ensuing number of this Journal.

† In the *Gardener's Chronicle* for July 18th, Mr. Bell calls attention to a passage in the *English Chronicle* for 1377 to 1461, published by the Camden Society, showing that in time of famine the people in the north of England were accustomed to make bread of Fern-roots.

less completely, into a pair of stamens, or a forked and biantheriferous filament; and so he concludes that the scales are composed of two abortive stamens united, "and in consequence that these two bodies do not constitute any real exception to the laws of alternation," nor arise from a transverse chorisis of the petal. But the advocates of *chorisis* will find no difficulty in these facts, and, agreeing with the writer in the Journal of Botany for 1849, that the scale belongs to the petal, will also maintain that its evolution into a double stamen in this case affords no proof nor presumption that the scale really represents a pair of true adnate stamens (any more than, *per contra*, the half-petal, half-stamen bodies of a semi-double Rose or Camellia are morphologically petals), so long as the theory of *collateral chorisis* is not invalidated,—since that theory just as well explains the double stamen of the case in hand as it does any other case. The same monstrous flowers clearly showed the carpellary origin of the ovules; and so perhaps as really do the normal blossoms of the same plant, with complete dissepiments at the base of the ovary.

Mr. Currey describes and figures (plate 2) a new species of *Pilolobus*.

Professor Lindley contributes a note on *Spiranthes gemmipara*, of the west coast of Ireland, and shows that it is neither our American *S. cernua* (as had of late been supposed, see p. 384 of this volume), nor *S. Romanzoffiana*. To this succeeds the longest paper in the faciculus, viz. Prof. Lindley's Contributions to the Orchidology of India, No. 1. "To nothing, perhaps, more remarkable does an examination of Indian Orchids lead, than to the unexpected fact that they show certain species to have a most extensive geographical distribution. Hitherto it has been believed that these plants are extremely local, and such is probably the case with epiphytes; but it is quite the reverse with terrestrial species, the range of some of which proves to be as wide as that of the most ubiquitous species belonging to other natural orders." This is illustrated by examples. We are interested to find that *Goodyera repens* inhabits the Sikkim Himalayas; and that Dr. Hooker also found there a *Tipularia*, which is characterized as a distinct species, but is not unlikely to be a mere variety of our own rare (but my no means local) *T. discolor*.

Mr. Oliver describes certain glandular appendages of the leaves in the autumnal rosettes of *Epilobium montanum;* and, finally, Dr. Hicks describes a new British species of *Draparnaldia*.

Since the foregoing notice was written, No. 5, or the first fasciculus of the second volume, has come to hand. The botanical portion comprises the following articles, besides the commencement of one from Dr. Thomson.

*On the Cultivation of Mosses*, by the Rev. H. H. Higgins. Mr. H. relates his experience in cultivating various mosses—about 240 species—in a *bryarium*, on the Ward-case principle.

*Synopsis of the Genus Clitoria;* by George Bentham.—The important points of general interest are, first, the union of *Neurocarpum* of Desvaux with this genus, for the same reason that the author reunites *Tetragonolobus* with *Lotus;* giving up the character, as generic, of a raised nerve or wing along the centre of the valves of the pod. Besides its being unaccompanied by other characters, in *Clitoria* it proves to be inconstant in the same species or even in the same individual. Mr. Bentham proceeds to remark that: "The external forms acquired by fruits in their development from the ovary to maturity, and especially the foliaceous appendages they assume, are sometimes irrespective of their organic struc-

ture, and appear then of little more consequence than the foliaceous wings or appendages on the branches, inflorescences, or calyx-tubes. So also the form of the membranous expansions of samaroid fruits, the consistence of pericarps, the number and arrangement on the calyx and other foliaceous appendages of the oleaginous deposits, called *transparent glands* in *Leguminosæ*, *Hypericineæ*, &c., or *vittæ* in *Umbelliferæ*, useful as they all may be in certain cases, as indicative of general organic differences, have yet *per se* but little absolute value in classification. This absolute reliance, in supposed conformity to general principles, upon such characters, even when unaccompanied by any other differences, is one of the sources whence botanical science is daily inundated by torrents of new genera, which threaten ere long completely to drown all system. Where the presence or absence of these appendages or glands, or any peculiarity in their arrangement, appears to be consequent upon a general difference in the plan of the fruit or in the habit of the plant, or is accompanied by corresponding characters in other organs, it should be carefully attended to. But where one or more species of a natural genus differ from the rest by some such external peculiarity in the development of the fruit alone, it seems against all principles laid down for a natural method, to take that peculiarity as a generic character, merely because it is a carpological one."

Another point brought to view is the until now unsuspectedly wide range of our *Clitoria Mariana*, which on the one hand extends from New Jersey to southern Mexico, while on the other it reappears in eastern India, viz. in the Khasiya mountains and Tavoy;—an interesting and unexpected addition to the list of such species recently published in this Journal. The writer adds that a Himalayan *Amphicarpæa* is so closely allied to our North American species, that the difference would probably vanish in a fuller suite of specimens. There is another Indian and Javan species of the same North American type:—"a fact which calls to mind how frequently large American genera (such as *Eupatorium*, *Aster*, *Solidago*, *Solanum*, &c.) are represented in Eastern Asia by a small number of species, which gradually diminish or disappear altogether as we proceed westward towards the Atlantic limits of Europe; whilst the types peculiar to the extreme west of Europe (excluding of course the Arctic flora) are wholly deficient in America. These are among the considerations which suggest an ancient continuity of territory between America and Asia under a latitude, or at any rate with a climate, more meridional than would be effected by a junction through the chains of the Aleutian and Kurile Islands."

*Præcursores ad Floram Indicam;* by Drs. Hooker and Thomson.—This is the first of a series of promised articles, which must for the present take the place of a continuation of the *Flora Indica:* it comprises the Indian *Stylidieæ* (3 species), *Goodenovieæ* (2 species), and *Campanulaceæ*, the latter including *Lobeliaceæ* as a tribe. There is no denying that this union is made on correct principles. But *Solanaceæ* should be combined with *Scrophulariaceæ* on the same grounds, as they probably would have been except for the great size of these families. Dr. Hooker has noticed dimorphous flowers in some species of Campanula, the abnormal ones being minute and "destitute of corolla and stamens" [?];—an interesting observation, but less novel than he supposes. For Linnæus (*Hort. Ups.* p. 40, so described the flowers of *Campanula* (*Specularia*) *per-*

*foliata;* Ruiz and Pavon figured them in *C. biflora;* Dr. Torrey noticed them independently in his *Flora of the Northern States* more than thirty years ago, and in 1830 described their true structure, (see also his *Flora of New York*, 1, p. 428). Since then, although overlooked by DeCandolle, they have been observed and investigated by Brongniart (*Jussieu, Mem. Malpigh.* in *Archives du Museum*, 3, p. 84), &c.—The vexed question of the principles of limitation of genera being raised, is discussed from a practical point of view by Dr. Hooker and Mr. Bentham; and an interesting note on the principles of generic nomenclature is drawn up by Mr. Bentham, in a separate article, which, being brief and important, we cite entire:—

*Memorandum on the Principles of Generic Nomenclature, as referred to in the preceding paper; drawn up by* G. BENTHAM, Esq., F.L.S.—"Two of the chief objects of the systematist in botany are, first, to collect plants into natural groups of successively higher value and greater scope according to their mutual affinities; and, secondly, to fix upon certain stages of these successive groups to which names should be attached for the purpose of reference. It is to the latter of these objects that we would now chiefly direct our attention.

"The grand object accomplished by Linnæus in his nomenclature was to create a language by which plants could be spoken of, and by means of which groups of species (called *genera*) could be referred to, classed, and treated of as easily as the species themselves.

"He accordingly, treating his genera as *entities* (to use a word of Jeremy Bentham's) as natural as species, distributed them for practical purposes into his well-known artificial Classes and Orders.

"The evident facilities for scientific study afforded by this grouping of species into natural genera, prompted Jussieu to carry the principle much higher; and, whilst he retained the Linnean genera as the basis of botanical language, he established, for the purposes of science, his *natural orders* or groups of genera, which are in fact nothing more than genera of a higher grade; and he distributed these orders or large genera into classes and subclasses. This system of—

Species grouped into natural genera,
Genera grouped into natural orders, and
Orders arranged in classes more or less natural;

with a language of—

Substantive names for the genera,
Adjective adjuncts for the species, and
Substantively taken adjectives for the orders,

has been ever since universally followed in theory, but has been most inconveniently departed from in practice.

"With the great increase in the number of species known, and the increased facilities for the study of affinities afforded by the Linnean language and the Jussieuan principles, botanists became aware that the species of a genus and the genera of an order could be collected into intermediate groups, as natural and as well defined as the genera and orders themselves; and that names were, for scientific purposes, as useful for these subordinate groups as for those genera or orders.

"To carry this into practice two different courses have been adopted:—

"1. To maintain the original genera and orders in their integrity (except where a mistaken view of their affinities required them to be remodelled),

calling the lower groups formed for scientific purposes *subgenera*, *sections*, *subsections*, *divisions*, &c., or *suborders*, *tribes*, *subtribes*, *divisions*, &c., as the case may be;—to maintain the original names for the purposes of language;—and, for the purposes of science, to give to the subordinate groups substantive or substantively taken adjective names as the case may be, whenever these subordinate groups are so well defined or so natural, that, *but for the convenience of language*, they might have made good genera or orders;—and, when these subordinate groups are less defined or less natural, either to give them no names at all, distinguishing them by figures or signs such as *, **, &c., or §1, §2, &c., or to give them mere adjective names.

"Or 2ndly. To consider even the lowest of these intermediate groups between species and original genera, or between genera and original orders, as so many independent genera or orders, with their corresponding substantive or substantively taken adjective names expected to be introduced into ordinary botanical language.

"The first of these courses appears to be the only one which can save botanical nomenclature from replunging into the chaos in which Linnæus found it. It was strongly advocated by the elder DeCandolle; although in the latter years of his life, seeing how general was the disposition to convert his subgenera and sections into genera, and his suborders and tribes into orders, he himself more or less gave in to the general practice. The same principle was adopted by Endlicher, but he again was disposed to go too far in giving substantive names to purely technical or ill-defined subsections of genera.

"The second course is that which is now unfortunately but too general. Independently of a natural pride we all feel in establishing new genera or orders, it is felt how useful it is, in the study of affinities, to define correctly and give names to all natural groups of every grade, however numerous they may be, and how easy it is, in the immense variety of language, to coin these names indefinitely; but it is not perceived that in attempting to introduce them all into ordinary botanical language, the memory is taxed beyond the capabilities of any mind, and the original and legitimate object of the Linnean nomenclature is wholly lost sight of. In a purely scientific point of view it matters little if the orders are converted into classes or alliances, the genera into orders, and the sections and subsections into genera; their relative importance does not depend on the names given to them, but on their height in the scale of comprehensiveness; but, for language, the great implement, without which science cannot work, it is of the greatest importance that the groups which give their substantive names to every species they include should remain large. If, independently of the inevitable increase of genera by new discoveries, such old ones as *Ficus*, *Begonia*, *Arum*, *Erica*, &c. are divided* into ten, twenty, thirty or forty independent ones, with names and characters to be recollected before any one species can be spoken of, if genera are to be reckoned by tens of thousands instead of thousands, the range of any individual botanist will be limited to a small portion of the whole field of the science. So also, as long as the number of orders

* And it must be borne in mind, that if genera so eminently natural and universally recognized as these, are to be thus subdivided and renamed for ordinary botanical parlance, so may *Carex*, *Rubus*, *Salix*, and hundreds of other equally well-established genera.

can be kept within, or not much beyond a couple of hundred, it may reasonably be expected that a botanist of ordinary capacity shall obtain a sufficient general idea of their nature and characters to call them at any time individually to his mind for the purpose of comparison; but double that number, and all is confusion.

"This inevitable confusion and the necessity of maintaining in some way the larger groups have been perceived by those even who have gone the farthest in lowering the scale of orders and genera. As a remedy they propose to erect the old genera into independent orders, and the old orders into classes or alliances. This is but an incomplete resumption of the old principles without the advantages of the old nomenclature.

"It must be recollected that, although we choose a well-defined and natural group as the one to which we give a generic name, yet this is no indication that the group is considered as the *best* defined, or better defined than the group immediately above it; on the contrary it is frequently less so. It is by no means pretended that *Urostigma* or *Pharmacosyce* are better defined than the old genus *Ficus*, or that the new genera that have lately been cut out of the old genus *Begonia* form more natural groups than *Begonia* itself does; but the principle in these cases seems to be adopted, that the lowest definable group above a species is a genus. Go a step farther, and every species becomes a genus with a substantive name!

"And let it not be forgotten, that although the analytical process carried to the uttermost is necessary for the purpose of ascertaining the facts upon which botanical science is based, it is a judicious synthesis alone which can enable the human mind to take anything like a comprehensive view of those facts, to deduce from them the principles of the science, or to communicate to others either facts or principles."

The philosophical side of the question remains to be discussed. It is much to be wished that Mr. Bentham would bring his sound judgment, logical acumen, and rich store of knowledge to bear upon the principles of botanical classification in general, and the grounds in nature upon which our systems rest. If *species*, and they alone, are the true subjects of classification; if the relationship of species is what the naturalist endeavors to express in the forms of genera, orders, classes, &c.; if these relationships are very various in degree, and even indefinite, so that the grades of affinity or groups they indicate are not always (and perhaps not generally) completely circumscribed in nature; and if, consequently, the definition of genera, &c. involves questions not of *things*, between which absolute distinctions might be drawn, but of *degrees of resemblance*, which may be expected to present indefinite gradations; then the suggestions of this article are as philosophical as they are practically useful, and the proper limitation of genera and other groups,—always the decisive test of a naturalist's genius—is a matter of sound judgment and sagacity, enlightened by wide experience, and not of arbitrary rules deduced from any preconceived system. A. G.

2. *Synopsis Plantarum Phanerogamicarum novarum omnium per annos* 1851–1855 *descriptarum;* auctore Dr. Carolo Mueller; or: Walpers *Annales Botanices Systematicæ*, tom. iv, fasc. 1. Leipsic, 1857. —Dr. Müller, it will be seen from this double title, has commenced a continuation of that necessary repertory of newly published species of plants, variously dispersed through memoirs, journals, and systematic works,

which the sudden death of Dr. Walpers arrested in the year 1850. Dr. Müller's first fasciculus, just issued, contains 160 pages, which are all occupied with the accessions in the few orders from *Ranunculaceæ* to *Nymphæaceæ*. This results not from an accumulation of new genera and species, but from the plan of the work and the style of printing being considerably altered, but not we think improved for the purpose in view. The principal part of this fasciculus is made up from the first volume of Hooker and Thomson's *Flora Indica*, and Tulasne's Monograph of *Monimiaceæ*, two books which every working botanist may be presumed to possess or have access to. So it was not worth while to copy detailed descriptions in full. Then, again, synonyms and varieties are displayed in separate paragraphs, and the page is in other respects so open that one might suspect it was intended to make the printed matter occupy the greatest amount of space, instead of the least. The more condensed a work of this kind is the better. While well-known and substantial works are so copiously abstracted from, rarer ones which we could mention and some scattered publications have been overlooked. Notwithstanding these faults, botanists can not be otherwise than thankful to Dr. Müller for carrying on so laborious and so necessary an undertaking. A. G.

3. *Bertoloni, Miscellanea Botanica;* fasc. 15 and 16 (1854, 1856, Bologna.)—About a quarter of a century ago Professor Bertoloni received from an American correspondent a set of a well-known collection of dried plants made in Alabama by the late Dr. Gates, and distributed by the New York Lyceum of Natural History. In 1844, in an evil hour, he began to publish new species from these materials. The extraordinary stupidity of the Italian Professor's determinations,—which may be judged of from the specimens already recorded in the pages of this journal,—would be simply amusing, if it were not for the trouble they give to botanists, in swelling most needlessly the lists of synonyms, already a serious hindrance to the progress of the science. It is just because Bertoloni's determinations are so very bad that they require to be noticed at all. For, as he rarely hits the family correctly, to say nothing of the genus, the ordinary means of correcting his mistakes are inapplicable. Fortunately rude figures of the proposed new genera and species are generally given; and these, with a knowledge of what Gates's collection contained, enable us to ascertain what the plants in question really are. We had hoped that the precious stock was exhausted, but the 15th and 16th fascicles of the *Miscellanea Botanica* afford the following novelties, viz.:

*Potamogeton delicatulum*, Bertol., which is P. hybridus of Michaux.

*Convolvulus condensatus*, which is

*Gentiana gracillima*, which is Nuttall's Apteria setacea, a well-known Burmanniaceous plant.

*Hibiscus trisectus*, described from foliage, without flowers or fruit, is the *Tread-softly* of the South, Cnidoscolus stimulosa.

*Polygala Pseudosenega*, although described as having rose-colored flowers, is pretty evidently P. lutea, a well-marked yellow-flowered species.

*Marshallia dentata*, is Gaillardia lanceolata, the rayless state, already notorious for having been formerly mistaken for *Polypteris, Nutt.* by DeCandolle.

*Myriophyllum fulvescens* is Proserpinaca pectinacea of Lamarck.

Besides these supposed new species, what Bertoloni names *Schrankia uncinata* is evidently *S. angustata.* A. G.

4. *Phycologia Australica, or Figures and Descriptions of Australian Seaweeds*, is the title of an illustrated work on the marine botany of Australia, announced by Dr. Harvey, Professor of Botany in the University of Dublin, on the plan of his *Phycologia Britannica*, so well known and so admirable. It is to be published by Mr. Reeve (if the number of subscribers' names warrant the undertaking), in fifty monthly parts, each with six colored plates and as many pages of letter-press, at three shillings sterling per part; and will contain the choicest fruits of the author's recent labors and discoveries upon the Australian shores. A. G.

5. *Indigofera Caroliniana*, of Walter, the common Wild Indigo-plant of the Southern United States, as Mr. Niesler informs us, is commonly used by the country people in Georgia in place of *I. tinctoria*, and it yields an indigo which to all appearance is equal to the commercial article. "Just when it is beginning to bloom, the old wives collect from the woods as much of the plant as they can procure; they steep it in water some twenty-four hours, until it assumes a greenish tinge, when the liquid is drawn off and *churned* until it assumes its proper blue color: it is then *curdled* by the addition of a small quantity of ley from wood ashes, and allowed to settle; the sediment is then collected, put into coarse bags and drained dry, and it is then used in the same way as the ordinary commercial article. Those who have used it most insist that the color is better and more permanent than that of the exotic indigo, and that the same quantity of the plant will yield much more than *I. tinctoria.* They are in the habit of cutting it three or four times in the season from the same root. Sometimes they gather the seed and sow it in convenient places, where it will flourish and yield a supply for years. It seems likely that this wild indigo might be made a profitable crop in the South; with this great advantage, that it would be produced on lands now waste and useless for any other purpose."—*H. M. Niesler, in litt.* A. G.

6. *The Crustacea and Echinodermata of the Pacific shores of North America;* by Wm. Stimpson. From the Journal of the Boston Society of Natural History, vol. vi, 92 pp. 8vo, with six plates. Cambridge: 1857.

*Prodromus Descriptionis Animalium Evertebratorum, &c.* Part II by Wm. Stimpson. Proceed. of the Acad. Nat. Sci. Philadelphia, 1857.

Mr. Stimpson has a great work before him in the description of the species of invertebrates which he collected in the recent North Pacific Expedition. In the first of these pamphlets he takes up the Crustacea and Echinoderms of the North American shores in that ocean. He elaborates with great care and skill, and appears to make sure work in his descriptions of species. With regard to the Crustacea, he states that now nearly 130 species of this region are known; among these there are many Maioids, but five Cancroids (four of the genus Cancer and one of Ozius) and none of the Portunidæ. The Lithodia group contains ten species. Mr. Stimpson adopts the generic name Eupagurus of Brandt instead of Bernhardus of Dana, the former having the priority of the latter by a month or two. He adds the *Cancer antennarius* to those of Cancer before described; and the Hippa of the California shores he makes a new species, the *H. analoga.* Besides these, his memoir includes many new species and some new genera.

The second pamphlet contains brief descriptions of new species of the Turbellaria Nemertinea, collected by the author in the course of the same expedition.

## IV. ASTRONOMY.

1. *New Planets.*—The 43d (*Ariadne*) of the system of little planets between Mars and Jupiter, was discovered April 15, 1857, by Mr. Pogson at the Radcliffe Observatory, Oxford, Eng. Its apparent brightness was about that of a star of the ninth magnitude. The following elements have been computed by Mr. Pape from observations at Oxford, April 15; Altona and Liverpool, April 19; and Bilk, April 22:

Epoch, 1857, April 22·5, Berlin m. t.

| | |
|---|---|
| Mean anomaly, - - - | 309° 16′ 23″·9 |
| Long. of perihelion, - - - | 276 34 59 ·1 |
| " " asc. node, - - - | 264 18 58 ·0 |
| Inclination, - - - - | 3 27 41 ·9 |
| Angle of excentricity, - - | 9 46 22 ·6 |
| Log. semi-axis major, - - - | 0·343405 |
| " mean daily motion, - - - | 3·034899 |

The 44th of this group was discovered May 27, 1857, by Mr. H. Goldschmidt, at Paris. Its brightness was that of a star of 10–11th magnitude.—*Astr. Jour., May* 30.

Another new planet was discovered June 27, 1857, by Mr. Goldschmidt at Paris.

2. *Second Comet of* 1857.—A comet was discovered, March 18, 1857, by Prof. C. Bruhns, of Berlin. It appeared as a small round nebula of 2′ diameter, with condensed nucleus, and without tail. Prof. B.'s computation seems to render it certain that this comet is identical with the third comet of 1846.—*Astr. Jour.*

3. *Third Comet of* 1857.—A telescopic comet of moderate brilliancy was discovered by Dr. Klinkerfues, at Göttingen, June 22, 1857.—*Astr. Jour. No.* 104.

4. *New Comet.*—A faint comet was discovered July 25, 1857, in the constellation *Camelopardalus*, by Dr. C. H. F. Peters, of the Dudley Observatory, Albany. The elements show that this comet is not identical with any of those expected to return this year.

5. *Zodiacal Light.*—In a recent paper read to the Royal Society by Professor Piazzi Smyth of Scotland, the author, after opposing the views of Rev. George Jones as published in his Japan Expedition Report, closes by saying, that he does not think Mr. Jones ever saw the zodiacal light at all. Surely this is a summary way of dealing with an author, and betrays no less arrogance than ignorance. We have compared observations at this place with those of Mr. Jones and know well his ability and fidelity in the investigation he has undertaken. It is true there is much to puzzle the theorist in the present state of the subject, but Prof. Smyth's way of sweeping the whole from science is a novel method of meeting the question.

## V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Schuyler Tornado, Oneida County, New York.* (From the Utica Morning Herald of June 17th, signed W.).—On Saturday, the 13th inst., at about 4 P. M., we witnessed in our own neighborhood one of those terrific manifestations of power, a tornado. That it was an unmistakable tornado or whirlwind,—water spout, as it would have been had it occurred upon the surface of the water instead of the land,—there can be no doubt.

Many noticed about 4 P. M. of that day a peculiarity in the appearance of the clouds, which for the most part lay to the northward of us. At Whitestown, where it did not rain at all; in Marcy some eight miles west of the scene of the disaster, and in Utica, a peculiarity in the clouds to the east was noticed by different observers. One observer in Deerfield described the appearance as a huge cone like a hogshead in the clouds, and terminating far below in a point the size of a stove pipe, which passed along towards the east, two observers say as long as ten minutes, one says swaying to and fro as it passed. It was black like the cloud itself, and when it touched the ground its course was attended with a dense dust like a fog, so that no object could be seen near its apex, upon the ground. Observers who were within a few feet of it, as it passed along, describe its rate of speed as at least twice as fast as any railroad train, say sixty miles an hour; others who saw it from behind and could not judge so well, suppose that it moved much slower.

At Schuyler Corners the phenomenon was very intelligently and carefully observed by Dr. Mower. He as well as others saw it first nearly north of the Corners but a little west, then presenting the appearance of a huge cone, apex down, suspended by its base from the cloud, its lower point apparently twenty or thirty rods above the earth, and not more than forty rods from their position to a point directly under it. It passed on to the east lengthening as it went. Having passed out of sight from an intervening house, he changed his position for a moment to gain a new view, and when he again saw it, it had touched the earth. Its course was now attended with a huge cloud of dust, and he could no more see the apex of it. At one time, it swelled out in the middle, forming as it were two cones base to base, the apices above and below, and a smaller and similar cone separated from it towards the south; this second phenomenon was traced by its progress upon the earth as noticed further on. He says he saw it ten minutes, and it seemed to pass slowly along.

It first struck the ground just back of the little hamlet of Schuyler Corners, and commenced its progress of destruction by demolishing fences, marking a very sharply defined path by leaving a length of fence undisturbed even to the top rail, while the next length were scattered; trees of various kinds were uprooted, and at length a barn upon the first road leading north from the turnpike east of Schuyler Corners, was struck, unroofed, and its boarding removed, leaving the frame apparently undisturbed.

Here the branch whirlwind appears to have diverged from the main tornado and marked its course by demolishing the well-house and four apple trees directly through the centre of an orchard leaving all the rest untouched. The well-house and all the trees were thrown towards the north, thus demonstrating the gyratory character of this smaller storm.

But the main storm passed on in its terrible path, not only demolishing fences, but even sweeping off thistles, elders, and the young oats now like grass without stalk. From observations made upon these herbs it was easy to notice that the course of the tornado was not only forward in a direct south-southeast course, but was also gyratory, revolving about its own center from the south around toward the east, thence around towards the north, thence directly contrary to the general direction of the storm towards the west, thence back again towards the south. Persons conversant with such matters will comprehend us better when we say that it revolved in a direction contrary to the sun or the hands of a watch.

But at length it struck Mr. Warren's dwelling. This apparently was a well built story-and-a-half frame house about sixteen by twenty-four feet; its sills of hewn beech eight by ten inches; its plates also hewn and of good dimensions, and altogether a well built frame house. It was lifted off its foundation, striking upon its roof; its west side now lying upon the east of this inverted house, is torn from the rest of the structure and driven fifty feet farther across the road, while the house itself is rolled farther over upon what was its west side and now lies with its east side upon the top, so flat that a dog could not crawl under it. This is sixty feet from the foundation, and among its ruins lie the furniture of the house. A heavy cooking stove lies turned over twenty-six feet from its old position. This no doubt broke through the side of the house or fell through some window or door in the progress of the house. More than one hundred feet from the site of the building lies the west side of the house before mentioned, and near it the sill, probably the west one, thirty feet long, eight by ten inches in size, hewn from beech wood!

But tremendous as the power must have been to accomplish so much, it next demonstrated its ability to do more. A few rods beyond Mr. Warren's demolished house, directly in the course of the storm, were two large apple trees, one of them a sturdy old tree larger than a man's body, say sixteen inches in diameter or three feet in circumference. This was not uprooted, but *twisted off at the root*, leaving no bigger hole in the ground than a bushel of earth would fill up again, and transported through the air, leaving no furrow or mark upon the sward, fifteen feet to the south, and laid down in a direction south-southeast, precisely in the line of the storm; the other, a somewhat smaller one, was treated in a precisely similar manner, affording fresh evidence of the gyratory character and direction of the storm. I estimate that two tons would be a low figure for the weight of this large apple tree. Two other apple trees on the edge of the storm, thirty feet north, were simply uprooted, and lie, one, the top towards the south, the other towards the southwest. I do not believe they were *blown down* by the tornado, but by the wind rushing in to fill the vacuum which the tornado left behind it, and the existence of which is more strongly proved by a phenomenon to be noticed farther on.

But the climax of the storm is yet to be seen. About three hundred feet directly south-southeast of the apple trees, upon an abrupt eminence say thirty feet high, there stood a first class farmer's barn, thirty-five by fifty feet, with a stone foundation, and with posts sixteen feet high. Its length was east and west, and its roof sloped towards the north and to-

wards the south. The south portion of the roof was carried north over a garden with fruit trees and deposited in a field beyond, some portion 200, some 300, and a large portion at least 500 or perhaps 600 feet from the barn; while the north side was carried just about as far towards the south. A threshing machine of iron and wood, said to weigh 400 pounds, was carried 230 feet south-southeast, and a sill or plate of the barn, weighing probably twice as much, lies near it, while huge timbers are beyond it, one 300 feet to the south, nine inches square by twelve feet long. Thus for 500 feet or more all around towards the north, east and south of this barn, lie its fragments, every timber and board removed from the greater portion of the foundation, and even the two inch hemlock plank floor of the basement of the west end of the barn, saturated with water, any one of them a load for two men, are lifted up and thrown together in a heap. This it must be understood is at the bottom of the basement some ten feet deep, protected by the stone foundation wall as it should seem from the direct action of the wind. Their removal can only be accounted for by the principle before alluded to, that the gyratory and probably upward motion of the wind produced a vacuum which the air below the basement floor rushed up to fill, raising the plank with it.

Beyond this, at the distance of a quarter of a mile, in the field, stood a slighter barn, technically a hay barn. Not one timber stands upon another of this barn, nor can any considerable portion be seen at all, to such an extent is it scattered.

But with the exception of a forest tree or so twisted off or stripped of its leaves, and fences demolished, no more mischief was done, and at the distance of less than a mile from the house of Mr. Warren this fearful visitant left the earth. Its destructive progress probably did not exceed two and one-half miles in extent, but was uncertain in width. Those living in the neighborhood do not place its width at over fifteen rods, and we should be inclined to think that except at the large barn where it seemed to expand its fury, its width was much less, say sixty feet. We saw no signs of electricity, and suppose that the twisted thistles and elders and leaves withering in the sun, gave all the evidence that any seemed to have of the existence of any such agent in the storm. It was unattended with thunder or lightning or much rain, but accompanied, as some say, with a little hail.

[In another account of this tornado, in the Utica Morning Herald of the 15th of June, it is stated that the whirlwind was not accompanied by any wind or storm, a fact to be especially noted; "it seemed like an independent agency, traveling on its own account;" and it states also that in its own intestine motion there was a constant revolution. The absence of wind around and the very narrow track of destruction as well as the abrupt boundary of this track, are much against a common notion that whirlwinds are made by a rush of air towards a centre from the region around it. The moving power, both of rotation and onward progress were not below but above. Moreover it is stated that the trees along its path, not uprooted, were left "green and healthful in the bud," with no mark of heat or any of the usual effects of electricity. We once observed a whirlwind of similar character but of miniature size in he Middle Pacific with no land in sight to produce eddies in the atmos-

phere. The day was bright and sunny, and the ship lay becalmed. The whirl appeared, half a mile to a mile off, as a very narrow column reaching from the cloud above to the water. But as it moved, it would seem to lose its hold on the waters, and disappear for want of vapor to render it visible,—and then again it formed its column anew as again it reached to the water's surface: and so it went dancing along over the ocean. From this marching on of a rapidly rotating whirlwind in a calm, it was evident at the time that whirlwinds were due to a motive power more or less independent of the lower atmosphere around them. It was evident in that calm unbroken sea that corners of streets or obstacles of rocks or mountains were not required to make whirlwind eddies. The small whirl was manifestly a type of the great tornado, for throughout nature the small and great have a common law, and the law is often best read by us in the small.—J. D. D.]

2. *Examination of a Nickel Meteorite, from Oktibbeha County, Mississippi;* by Wm. J. Taylor, (Proceedings of the Acad. of Nat. Sci. of Philad., April, 1857.)—This highly interesting and unique meteorite was found in an Indian mound in which excavations were being made in a search for Indian antiquities, in Oktibbeha County, Mississippi. It then weighed five and a quarter ounces; in shape it resembled a hen's egg. When found, there was a fissure which divided it almost equally into two parts. The person who discovered it seeing this, placed it upon an anvil, and with one blow of a sledge-hammer, divided the meteorite. One half was forged, with the intention of manufacturing it into a cutting instrument of some description; the other remained in its original state, excepting that its exterior was filed smooth and bright.

To Dr. William Spillman, of Columbus, Mississippi, I am indebted for material for this investigation; he obtained the meteorite from the man who first found it. The unforged half he brought with him on a recent visit to this city, and a portion of which he has presented to the Academy, on the condition that it should be carefully cut, so that the surface which formed one side of the existing fissure above mentioned should be preserved and sent to him. It was proposed to have it cut by a lapidary, but he attempted it without success, using diamond dust on the wheel. On making the first incision, about one-eighth to one-sixteenth of an inch in depth, he found it impossible to proceed, and refused to make farther attempts to cut the meteorite. Mr. John Phillips, a fellow member of the Academy, and an amateur machinist, on hearing of our difficulties, kindly offered to saw the specimen, and succeeded admirably, though it was with very great difficulty. He spoke of its peculiar toughness, (the hardness not being excessive;) it resisted the saw very much, which rendered the cutting exceedingly tedious, heating the saw to such a degree as to oblige a discontinuance of the operation every four or five minutes, but it was remarkable that it did not dull the blade in the least.

The toughness of the iron was clearly shown when, for the purpose of analysis, it was attempted to cut off portions of it with a chisel; the excessive toughness of the iron rendered this very difficult, without the aid of the saw. The resistance of this meteorite to the action of acids was most remarkable. Strong nitric acid did not act upon it in the cold. Moderately dilute sulphuric acid did not act upon it. Strong and boiling hydrochloric acid acted upon it very gradually.

The above named acids failing to show the slightest trace of the Widmannstättian figures; a mixture of nitric acid and hydrochloric was used, boiling, but even after this operation no trace of them could be distinguished. The action of the aqua regia was gradual and peculiar, producing on the polished surface of the meteorite very small holes, varying in size from a pin's point to those as large as a pin's head. From the appearance of the surface of the meteorite, which formed a side of the fissure before described, I had hoped to obtain by etching beautiful Widmannstättian figures, as there is on this portion indistinct traces of that which would at first glance be called a crystalline structure.

The color of the metal is a silvery grey with a pinkish tinge. Its hardness is not excessive, yielding readily to the file. The tensibility, as before mentioned, was very great. The passivity was proved by testing it with a neutral solution of the sulphate of copper.

The specific gravity at 25° Cels., was found by Dr. F. A. Genth to be 6·854, which is too low, but owing to the numerous fissures through the meteorite filled with limonite, it was impossible to obtain the exact specific gravity of the metal. I used particular care to obtain a portion free from the flaws, but without effect. I take this opportunity to express my thanks to Dr. Genth for allowing me the use of his laboratory in making the examination. The following is the result of my analysis:

1·9421 grammes were dissolved in aqua regia.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1·4731 | grams. | NiO | gave of | Nickel | 59·69 | per cent. |
| 1·0452 | " | $Fe_2O_3$ | " | Iron | 37·69 | " |
| 0·0221 | " | CuO | " | Copper | 0·90 | " |
| 0·0072 | " | $Al_2O_3$ | " | Aluminium | 0·20 | " |
| 0·0105 | " | $Co_6O_7$ | " | Cobalt | 0·40 | " |
| 0·0048 | " | $SiO_3$ | " | Silicium | 0·12 | " |
| 0·0069 | " | $2MgO, PO_5$ | " | Phosphorus | 0·10 | " |
| 0·0059 | " | $CaO, CO_2$ | " | Calcium | 0·09 | " |
| | | | | | 99·19 | |

The slight loss of eight-tenths of one per cent I think is owing to some small portions of limonite existing in the minute fissures already mentioned.

The 0·10 per cent of phosphorus correspond to 0·64 per cent of schreibersite, ($P Ni^2 Fe^4$).

It was first attempted to dissolve in hydrochloric acid, but the action of the acid, even when boiling, was so very gradual that nitric acid was added.

I endeavored to separate the nickel and cobalt by Liebig's new method, viz., by precipitating the nickel as a sesquioxyd, by passing chlorine through an alkaline solution of the two metals in hydrocyanic acid and potash, but it was found not to answer; the separation was made by his former method by oxyd of mercury.

The composition of this remarkable meteorite is in itself sufficiently interesting for mineralogists, without any attempts to account for its origin, either terrestial or celestial. We must remain in doubt as to the exact locality where it was originally found, as it may have been carrried by the Indians from a distance to be entombed in this mound, and it may

have been considered by them to have a special value, and possibly to possess peculiar virtues, from its being discovered in such a place.

3. *Meteoric Iron of Mexico.*—Meteoric iron from near Xiquipilco has been described and analyzed by Dr. Evan Pugh as follows (Ann. der Ch. u. Pharm., xcviii, 383, from his Inaug. Dissert. Göttingen, 1856).

No. 1. A piece of a specimen weighing 200 pounds. It has a thick crust of oxyd, in which are many yellow metallic spots of schreibersite. There are also yellow drops of the chlorid of iron. Texture within, coarse foliated, crystalline with large crystalline figures like the iron of Elbogen. Not passive. Yields sulphuretted hydrogen with dilute muriatic acid showing that it contains magnetic pyrites. Different trials showed that it contained 0·9 to 1·24 per cent of black insoluble material, consisting of phosphuret of nickel and iron, graphite, and microscopic grains of a yellowish colorless mineral.

No. 2. Specimen weighing 19½ lbs. Less oxydized than the preceding. Contains spots of schreibersite and also shows the yellow chlorid of iron in drops. In its interior there are greenish grains of *olivine*. Hardness greater than in the preceding. Texture broad crystalline, showing large figures. Not passive. No sulphuretted hydrogen with hydrochloric acid. Insoluble residues 0·568 to 1·58 p. c. consisting of schreibersite, graphite and grains of a colorless, a ruby red, and a greenish mineral.—Analyses:

| | | Fe | Ni | Co | P | Mn | S | Cu, Sn | Sch'site. | Graphite, &c. |
|---|---|---|---|---|---|---|---|---|---|---|
| I. | *a.* | 90·43 | 7·62 | 0·72 | 0·15 | —— | 0·03 | 0·03 | 0·56 | 0·34=99·88 |
| | *b.* | 90·08 | 7·10 | —— | —— | —— | 1·24 | | | |
| II. | *a.* | 87·89 | 9·06 | 1·07 | 0·62 | 0·20 | —— | *trace* | 0·34 | 0·22=99·41 |
| | *b.* | 88·28 | 8·90 | 1·04 | 0·78 | | | | | |
| | *c.* | 87·88 | 8·86 | 0·89 | 0·86 | | | | | 1·24 |

The oxydized crust consists of

| Ḟe | Ḣ | S̈i | Ä̇l | Ṁg | Fe | Ni | Co | P | Schreibersite. |
|---|---|---|---|---|---|---|---|---|---|
| 51·49 | 13·27 | 7·47 | 0·79 | 0·21 | 20·51 | 4·13 | 0·40 | 0·18 | 0·66=99·11 |

4. *Meteoric Stone.*—A meteoric stone fell on the island Oesel on the 11th of May, 1855, and is described by A. Göbel (Pogg. xc, 642). Specific gravity 3·668. Magnetic part 13·07 p. cent, containing nickeliferous iron 12·75, FeS 0·25, insoluble chromic iron 0·04, soluble chromic iron 0·01, phosphuret of iron and tin, 0·01. Non-magnetic part 86·93 p. c.; of which 46·86 is soluble in muriatic acid, and affords Olivine 41·13, sulphuret of iron 5·59, chromic iron 0·11, phosphuret of iron 0·03; 40·08 p. c., insoluble in muriatic acid, affords labradorite and hornblende 38·88, insoluble chromic iron 0·40, soluble chromic iron, phosphuret of iron 0·23. There is a trace also of manganese, cobalt, carbon, sulphur.

A fall took place near Civita Vecchia, in the sea, Sept. 17, 1856, near 10½ p. A. M. It was of large size, had a long trail and made a loud sound as it struck the water.

5. *Meteoric Stone.*—A meteoric stone fell near Bremervörde on the 13th of May, 1855, which broke into many pieces, the largest of them weighing 25 pounds, 29 loth, according to Wöhler (Ann. d. Ch. u. Pharm., xcix, 244). It has a thin crust and is grayish within. Composition:

Fe 21·11, Ni 1·89, S̈i 45·40, Ṁg 22·40, Ḟe 4·36 Ä̇l 2·34, Ṅa 1·18, K̇ 0·37, chromic iron 0·30, graphite 0·14, Co, P, Ċa, Ṁn *traces* =100. The Ḟe was estimated from the loss.

6. *Meteoric Stone.*—A stone fell in East Flanders a German league from Gent on the 7th of June, 1855 at $7\frac{3}{4}$ hours in the evening. A piece of it procured by Mr. Duprez weighed 700·5 grams. Specific gravity 3·293.—*Pogg.* xcix, p. 64.

7. *Cabinets of Minerals for sale.*—Dr. F. A. Genth of Philadelphia offers for sale a valuable collection of minerals containing nearly 3100 specimens, among which he states there are many beautiful and rare crystallizations. Prof. Keating's cabinet, advertised a year since as on sale, is still in the hands of Dr. Genth, and could be had for $1000. The attention of colleges and other institutions to these cabinets is commended.

Dr. Genth also states that he has another mineral collection of small size, containing 700 specimens one and a half inches by two in size, which may he purchased for $175. And in addition, a collection of geological and palæontological specimens, 2500 in all, which he brought with him from Europe.

8. *Ray Society, (established* 1844) *for the publication of works on Natural History.* Subscription, one guinea a year.—The Council of the Ray Society, feeling that the objects it has in view are not sufficiently known, beg to call attention to the circumstances which gave rise to its existence. For many years previous to 1844, naturalists had felt the necessity of combining for the distinct purpose of bringing out some of the more important works on natural history, which existing societies could not publish, and which would not be undertaken by any publisher. It was also felt very desirable to reproduce some of the older standard works of British naturalists, and, by translation, to introduce to the British public the more important works on natural history published on the continent, more especially in Germany. For the accomplishment of these objects, the Society commenced its labors in 1844, and has since published the following works:

*For the first year*, 1844.—I. Reports on the Progress of Zoology and Botany; translated by Hugh E. Strickland, Jun., Esq., M.A., F.R.S., E. Lankester, M.D., F.R.S., and W. B. Macdonald, Esq., B.A. 8vo, pp. 498.

II. Memorials of John Ray: consisting of the Life of John Ray, by Derham; the Biographical Notices of Ray, by Baron Cuvier and M. Dupetit Thouars, in the Biographie Universelle; Life of Ray, by Sir J. E. Smith; the Itineraries of Ray, with Notes by Messrs. Babington and Yarrell; edited by E. Lankester, M.D., F.R.S. Frontispiece. 8vo, pp. 230.

III. A Monograph (with colored drawings of every species) of the British Nudibranchiate Mollusca; by Messrs. Alder and Hancock. Part I. Imp. 4to.

*For the second year*, 1845.—I. Steenstrup on the Alternation of Generations; translated from the German by Geo. Busk, Esq., F.R.S. Three plates. 8vo, pp. 132.

II. A Monograph of the British Nudibranchiate Mollusca, with thirteen colored illustrations in litho-tint; by Messrs. Alder and Hancock. Part II. Imp. 4to.

III. Reports and Papers on Botany, consisting of translations from the German; translated by W. B. Macdonald, Esq., B.A., G. Busk, Esq., F.R.S., Arthur Henfrey, Esq., F.R.S., and J. Hudson, Esq., B.M. Seven plates. 8vo, pp. 494.

*For the third year*, 1846.—I. Meyen's Geography of Plants; translated from the German by Miss Margaret Johnston. 8vo, pp. 422.

II. Burmeister on the Organization of Trilobites, with six plates; translated from the German, and edited by Professors Bell and E. Forbes. Imp. 4to, pp. 136.

III. Alder and Hancock's British Nudibranchiate Mollusca, with 11 colored plates in litho-tint. Part III. Imp. 4to.

*For the fourth year*, 1847.—I. Oken's Elements of Physio-Philosophy; translated from the German, by Alfred Tulk, Esq.

II. Reports on the Progress of Zoology; translated from the German, by George Busk, Esq., F.R.S., A. H. Halliday, Esq., and Alfred Tulk, Esq. 8vo, pp. 680.

III. A Synopsis of the British Naked-eyed Pulmograde Medusæ, with 13 colored plates, drawings of all the species; by Professor E. Forbes, F.R.S. Imp. 4to.

*For the fifth year*, 1848.—I. Bibliographia Zoologiæ et Geologiæ; by Professor Agassiz of Neufchatel, edited by Hugh E. Strickland, Esq., M.A., F.R.S. Vol. I. 8vo, pp. 506.

II. The Letters of John Ray; edited by E. Lankester, M.D., F.R.S. Two plates. 8vo, pp. 502.

III. Alder and Hancock's Nudibranchiate Mollusca, with colored illustrations. Part IV. Imp. 4to.

*For the sixth year*, 1849.—I. Reports and Papers on Vegetable Physiology and Botanical Geography; edited by A. Henfrey, Esq., F.R.S. Three plates. 8vo, pp. 514.

II. A Monograph, with 36 plates (mostly colored), of all the species, of the British Entomostracous Crustacea; by Dr. Baird, F.L.S. 8vo, pp. 364.

*For the seventh year*, 1850.—I. Vol. II of the Bibliographia Zoologiæ et Geologiæ. 8vo, pp. 492.

II. Part V of Alder and Hancock's Nudibranchiate Mollusca, with 15 plates, 12 colored. Imp. 4to.

*For the eighth year*, 1851.—I. A Monograph of the British Angiocarpous Lichens, with 30 colored plates; by the Rev. W. A. Leighton, M.A. 8vo, pp. 100.

II. A Monograph, with 10 copper-plates and other illustrations, of the Family Cirripedia; by C. Darwin, Esq., M.A., F.R.S. Vol. I. 8vo, pp. 400.

*For the ninth year*, 1852.—I. Vol. III of the Bibliographia Geologiæ et Zoologiæ. 8vo, pp. 657.

II. Part VI of Alder and Hancock's Nudibranchiate Mollusca, with 12 plates, 11 colored. Imp. 4to.

*For the tenth year*, 1853.—I. Vol. II of Darwin's Monograph on the Cirripedia, 30 plates. 8vo, pp. 684.

II. A volume of Botanical and Physiological Memoirs, including Braun on Rejuvenescence in Nature, 6 plates, colored. 8vo, pp. 568.

*For the eleventh year*, 1854.—Vol. IV of the Bibliographia Geologiæ et Zoologiæ. 8vo.

*For the twelfth year*, 1855.—Part VII of the Nudibranchiate Mollusca, with nine plates, concluding the work; by Messrs. Alder and Hancock.*

* By a minute of Council, subscribers for 1854 and 1855 alone are entitled to select a volume in addition for each year from the past year's publications.

It will be seen that these works are not only valuable contributions to science, but that some of them are unequalled in the literature of natural history; and although an ample return to the members for their guinea subscriptions, the Council could have increased both their number and value had the funds at their disposal enabled them to do so.

The subscribers to the Society have never yet exceeded 1000 members, and as the Council are continually obliged to defer the publication of valuable works, on account of their limited resources, they hope that by bringing the claims of the Society more prominently before naturalists and the patrons of science, they may thereby meet with encouragement to widen the field of their labors.

The following are amongst the works which the Council have already engaged to publish in succeeding years:

(1.) A Monograph of the British Freshwater Polyzoa, by Professor Allman, F.R.S.

(2.) On the Oceanic Hydrozoa, by T. H. Huxley, Esq., F.R.S.

(3.) A Monograph of the British Foraminifera, by Professor Williamson, F.R.S.

(4.) General History of the Foraminifera, by Dr. Carpenter. 4to.

(5.) A Monograph of the British species of Spongiadæ, by J. S. Bowerbank, Esq., F.R.S.

(6.) A Monograph of the British Araneidæ, by J. Blackwall, Esq.

(7.) The Travels of Linnæus in West Gothland, translated by G. B. Lewin, Esq., M.A. 8vo.

(8). A Supplement and Index to the Bibliography. 8vo.

Whilst the Council feel that each of their members receives an equivalent for their subscription, they look also to support from those who would be glad to assist in a great scientific work, independent of any immediate benefit to be derived therefrom.

Persons desirous of joining the Society may do so by applying to any of the members of the Council, or the Secretaries.

*Officers and Council of the Ray Society.*—*President*, Professor Bell, Pr.L.S., F.R.S.—*Council*, Prof. Allman, Prof. D. T. Ansted, Chas. C. Babington, Esq., Robert Ball, Esq., LL.D., Prof. Busk, W. B. Carpenter, M.D., Prof. Daubeny, M.D., Sir P. de M. G. Egerton, Bart., Prof. Goodsir, M.D., Prof. Henfrey, Joseph Hooker, M.D., Robert Hudson, Esq., T. H. Huxley, Esq., Sir W. Jardine, Bart., Rev. Leonard Jenyns, Prof. Owen, D.C.L., Robert Patterson, Esq., Pres. Nat. Hist. Soc. Bel., Prof. John Phillips, Prideaux J. Selby, Esq., G. Waterhouse, Esq., W. Yarrell, Esq.—*Treasurer*, J. S. Bowerbank, Esq., 3 Highbury Grove, Islington.—*Secretary*, E. Lankester, M.D., LL.D., 8 Savile Row, London.

*Extracts from the Laws of the Ray Society.*— * * * *

II. Every subscriber of one guinea annually to be considered a member of the Society, and to be entitled to one copy of every book published by the Society during the year to which his subscription relates; and no member shall incur any liability beyond the annual subscription.

III. That the annual subscriptions shall be paid in advance, and considered to be due on the first day of January in each year; and that such members as do not signify their intention to withdraw from the Society before the second day of June, shall be considered to continue members, and be liable to the year's subscription.

9. OBITUARY.—*Prof. Elisha Mitchell.*—We are pained to announce the death of Rev. Dr. MITCHELL, Professor of Chemistry in the University of North Carolina. It occurred by a melancholy accident, among the Alleghany mountains, near the eminence which bears his name, on the 27th of June last. A few years since he had explored the lofty mountains lying in the western part of North Carolina, and had ascertained the height of a peak of the Black Mountain range, to be greater than any elevation east of the Rocky Mountains. It has since been called "Mount Mitchell," and is so denominated by geographers. Some discussion having arisen between him and the Hon. Mr. Clingman, respecting the relative heights of this and another mountain of the same range, he was at the time of his death engaged in a new measurement of those peaks, aiming at the same time to serve the cause of science, by establishing a series of levels in connection with a railroad survey in progress in that country. On the 27th of June, Dr. Mitchell had left his hotel alone, and on foot, intending to cross a wild region to a place about ten miles distant, where he was to join his son and daughter, who had accompanied him on the excursion. Not arriving at the appointed station, the alarm was spread, and after eleven days, his body was found in a river at the foot of a precipice from which he must have fallen, as was evident from a branch of laurel which was broken off and was still grasped in his hand.

Professor Mitchell was born in Washington, Conn., August 19, 1793, and graduated at Yale College, with distinction, in the class of 1813. He was tutor from 1816 to 1818, at which time he was elected Professor of Mathematics in the University of North Carolina. In 1825 he was transferred to the chair of Chemistry, Mineralogy and Geology. Having served the institution with faithfulness and ability for nearly forty years, and made valuable contributions to science, his death is deeply lamented. The State of North Carolina, especially, has evinced for him the highest degree of respect and affection, and is contemplating distinguished honors to his memory. O.

Prince CHARLES LUCIEN BONAPARTE the ornithologist, died early in August, aged 54 years; AUGUSTIN CAUCHY the mathematician, on the 23d of May at Paris, aged 78 years; THENARD the chemist, at Paris, in June last.

10. *Climatology of the United States*, and of the Temperate Latitudes of the North American Continent, embracing a full comparison of these with the Climatology of the temperate latitudes of Europe and Asia, and especially in regard to Agriculture, Sanitary investigations and Engineering, with Isothermal and Rain Charts for each season, the extreme months and the year, including a Summary of the Statistics of Meteorological observations in the United States, condensed from recent scientific and official publications; by LORIN BLODGET, author of several reports on American climatology; member of the National Institute and of various learned societies. 536 pp., large 8vo, with several maps. 1857. Philadelphia: J. B. Lippincott & Co. London: Trübner & Co. $4.00 in cloth.—The contents of this new volume on meteorology are given in the above cited title. It treats of the subjects in a comprehensive manner, embracing a large part of North America as its field, and bringing this great region into its place with reference to the globe. It aims especially to present the geography of temperature and

of rain and snow for temperate North America; and besides discussing the peculiarities of the different parts of the country east and west, north and south, it illustrates the distribution by large and neatly made charts like those of Berghaus's great work, republished in Johnston's Physical Atlas. These charts are, an isothermal chart for each of the four seasons, and one for the year; and the same number of "hyetal" or rain charts. In addition to these there is a temperature and a hyetal chart for the whole north temperate zone of the globe. The charts relating to the United States are very similar to those published in the Army and Meteorological Register in 1855, which work has been noticed in this Journal. They have undergone however some important modifications from the collection of more recent facts; yet of course can now only claim to express the present state of knowledge on the subject.

We have not space at this time to discuss or present the views or conclusions brought forward by the author, or to attempt any special verification of his lines of temperature and rain regions. Science owes much to his labors. The work is greatly in advance of any hitherto published on American climatology. His descriptions and charts are full of instruction and go far towards enabling us to comprehend the nature of the grand system of atmospheric temperature, winds and moisture.

Mr. Blodget, besides enjoying the advantages derived from his connection with Dr. Coolidge in the collation and study of the army meteorological observations, was also for a while in charge of the meteorological department in the Smithsonian Institution; and to both of the sources of facts here mentioned he is largely indebted for the means of preparing this important survey of American climatology. The publishers have issued the volume in excellent style and at a very low rate for a work so large and so well illustrated.

11. *Explorations in the Dacota Country in the year* 1855; by G. K. Warren, Topographical Engineer of the Sioux Expedition, 80 pp. 8vo. Washington, 1856. Exec. Doc., No. 76, 34th Congress, 1st Session.—The Government Explorations of the Rocky Mountain Slopes are adding much to science as well as general geography. Lieut. Warren's Report, is mainly topographical, but gives also information on the distribution and peculiarities of the Indians of the Dacota Country, some geological observations, and important meteorological tables. It closes with a sketch of some of the geological and physical features of the region of the Upper Missouri, with notes on its soil, vegetation, &c., by F. V. Hayden.

12. *Maury's Wind and Current Charts; Gales in the Atlantic.* Pamphlet in 4to, of 24 charts. Observatory, Washington, May 1857.—This quarto pamphlet by Lieutenant Maury, consists of a series of charts of the North and South Atlantic, exhibiting by means of colors the prevalence of gales over the more stormy parts of the oceans, for each month in the year. One color shows the region in which there is a gale every 6 days, another color every 6 to 10 days, another every 10 to 14 days, and there is a separate chart for each month and each ocean. The author observes that this is the first attempt to delineate the rain regions over these oceans, and that although the result has cost much labor it is necessarily imperfect in consequence of the few observations as data on which he has had to rely. It is an initial step in an important work.

13. *Smithsonian Report for* 1856.—The Annual Report of the Smithsonian Institution for 1856, contains, besides other details, a report on the progress of the Zoological Museum, which has increased in six years from almost nothing to about 12,000 species, mostly from the Government Surveying Expeditions through the west, and the labors of Prof. S. F. Baird; also abstracts of the lectures delivered before the Institution during the year; a paper by Prof. Henry on the mode of testing building materials; a continuation of a Report on the Progress of Physics, besides other scientific papers.

14. *Proceedings of the American Association for the Advancement of Science.* 10th Meeting, held at Albany, New York, August, 1856. 260 pp., 8vo, Cambridge, 1857. Published for the Association by JOSEPH LOVERING, Permanent Secretary.—The American Association is greatly indebted to Prof. Lovering for the care he has bestowed in the printing and publication of the proceedings.

15. *Eleventh Meeting of the American Association.*—The eleventh meeting of the American Association for the Advancement of Science opened at Montreal on Wednesday, the 12th of August last. The president elect, Professor J. W. Bailey, having died during the year, the vice president, Professor Caswell of Brown University, was the acting President. The number of members in attendance was as large as at any previous meeting. Mr. Ramsay was received as delegate from the Geological Society of London, and Mr. B. Seeman, from the Linnæan Society of London. The departments of astronomy, physics, meteorology and geology, were well represented by papers, and especially the last, and there were also important communications in ethnology; while in zoology, botany, and chemistry, the communications were exceedingly few. A biographical memoir of Mr. William C. Redfield, the first president of the Association, was read by Professor D. Olmsted, and one of Professor Bailey, by Dr. A. A. Gould of Boston. The retiring President, Prof. James Hall, delivered an address on American Geology.

Commodious accommodations for the meetings, were afforded the Association, at the Court House, by the government of Canada, and generous attentions by citizens of Montreal. Each member was furnished on arrival with a large folded card, containing, on one side, a plan of the Court House, a list of the officers of the Association, and an enumeration of the places of public interest in and about Montreal, and on the other, a map of the city of Montreal and of the St. Lawrence adjoining with its islands, and also a colored geological map of Canada for a circuit of fifty miles around Montreal, showing the outlines of the formations as laid down by Sir William E. Logan, under whom the geological survey is still in progress.

One of the principal objects of attraction in the city, was the Geological Museum, containing the collections made in the course of this survey. It was remarkable for the extent and variety of rock-specimens, and the great number and beauty of the fossils; no geological survey on this or any other continent has been carried forward with greater energy or skill.

The following is a list of the papers presented at this meeting. As in other cases, we publish no abstracts of papers read, except such as may be furnished us by the authors. The Edinburgh Philosophical Journal

the past year has done injustice to many authors, by making citations from the newspaper reports of the papers read at the Albany meeting.

## I. *Mathematics, Physics, Meteorology, and Chemistry.*

On the Zodiacal Light; by Charles Wilkes, U. S. N.

Observations on the Zodiacal Light at Quito, Ecuador, with deductions; by Rev. Geo. Jones, U. S. N.

On the Vibrations of the Fall over the Dam at Holyoke, Mass.; by E. S. Snell.

Hypothesis concerning Meteoric Stones; by Robert Burns.

Notes on the measurement of a base line on Epping Plains, Washington county, Maine, for the Primary Triangulation of the eastern section of the coast of the United States; by A. D. Bache.

On the Winds of the Pacific Coast of the United States; by A. D. Bache.

On the heights of the Tides of the Atlantic coast of the U. States; by A. D. Bache.

Solar Eclipse of March 14–15, 1858; by Thomas Hill.

A note on Arithmetical Complements; by Thomas Hill.

On a System of Co-ordinates in Analytic Geometry; by Thomas Hill.

Note on the Gyroscope; by B. Peirce.

Note on the Conservation of Force; by B. Peirce.

On the diverse Weights employed in modern Coinage; by J. H. Gibbon.

On a new source of Electrical Excitation; by Mrs. Elisha Foote.

On the physical conditions determinate of the climate of the United States; by Joseph Henry.

On some Phenomena of Ice; by Joseph Henry.

On the influence of the Gulf Stream upon the Climate of the Atlantic coast of the United States; by Dr. James Wynne.

On the application of a new arrangement of Locomotive Boiler, to the combustion of Coal; by Dr. James Wynne.

On the warped surfaces occurring in Road Excavations and Embankments; by W. M. Gillespie.

Preliminary Researches on the alleged influence of Solar Light on the Process of Combustion; by John LeConte, of South Carolina College.

On some special relations of the Straight Line and the various orders of Curves; by Stephen Alexander.

Of the Special Harmonies of the Distances and the Periodic times of the bodies composing the Solar system, and the physical hypothesis to which this state of things seems to be referable; by Stephen Alexander.

Some farther statistics and inquiries with respect to the form, magnitudes, &c., of the Asteroid Planets; by Stephen Alexander.

Some of the phenomena of the Texas "Norther" and Climatology; by G. C. Forshey.

Improvement in the construction of the Achromatic Telescope; by H. L. Smith, Kenyon College, Gambier, O.

On an improved construction of Ruhmkorff's Induction Apparatus; by E. S. Ritchie.

On the Electrical Hypothesis of the Aurora Borealis; by D. Olmsted.

Some observations respecting a Steam-boiler Explosion at Haverhill, Mass.; by James R. Nichols.

On a series of new Meteorological and Physical Tables prepared for the Smithsonian Institution; by A. Guyot.

On the Barometric formulæ for the measurement of differences of level by the Barometer, and a proposed modification of Laplace's Constant; by A. Guyot.

On the idea of Physical and Metaphysical Infinity; by E. B. Hunt, Lieut. U. S. Engineers.

Memoir on the Molecular Constitution of Material Masses; by E. B. Hunt, Lieut. U. S. Engineers.

Paper on Weights and Measures; by G. M. Dexter.

On a new Electro-magnetic Governor for Uniform Motion; by J. H. Lane.

Sketch of a plan proposed for reducing observations upon periodical Phenomena to a series of mean dates, and the advantages of this method of developing the Laws of Climate; by Franklin B. Hough.

On Ozone; and on the Meteorology of Montreal; by C. Smallwood.

Lateral Pressure of Running Water; by Thomas Green.

On a new Maximum Thermometer; by Thomas Green.

On a new method of Determining the Commercial value of Saltpetre; by E. N. Horsford.

An enquiry into the causes of a peculiar discoloration of Coffee, which had been stored in the same building with Guano; by Dr. Lewis H. Steiner.

## II. *Geology and Natural History.*

On the Flexures of the Strata in the Broadtop Coal Field, Pennsylvania; by J. P. Lesley.

On Comparative Sections in Western Kentucky, and Western and Eastern Pennsylvania; by J. P. Lesley.

On the Variety and Preservation of the Sternbergia; by J. W. Dawson.

On the Newer Pliocene Fossils of the St. Lawrence Valley; by J. W. Dawson.

On the division of the Azoic Rocks of Canada into Huronian and Laurentian; by Sir W. E. Logan.

On the probable subdivision of the Laurentian series of Canadian Rocks; by Sir W. E. Logan.

On the relative dates of the various intrusive Rocks, cutting the Laurentian Series in Canada; by Sir W. E. Logan.

On some Mineral Waters, and on the origin of Magnesian Rocks; by T. S. Hunt.

On the Parallelism between the rocks of the Laurentian and Silurian Systems; by T. S. Hunt.

On some intrusive rocks of the District of Montreal; by T. S. Hunt.

General Considerations on the Metamorphism of the Sedimentary Rocks; by T. S. Hunt.

On a subsidence on the Coast of New Jersey and some of the adjoining States; by Geo. H. Cook, Rutger's College.

Notice of a New System of Dressing Metallic Ores; by B. Silliman, Jr.

On some Debatable Points in Natural Science; by E. J. Chapman, Toronto.

On a Species of Trilobite and Pleurotomaria from the Potsdam Sandstone of New York; by J. D. Dana.

On the General Plan and Mode of conducting the Geological Survey of Great Britain; by A. C. Ramsay.

On the Physical Break and the Break in the Succession of Life in the British Rocks; by A. C. Ramsay.

On the place in the Geological series of the masses of Crystalline or Sub-crystalline Stratified Rocks, in the North Highlands of Scotland; by Sir Roderick Murchison, with a Note on the Fossils by J. W. Salter.

On Graptopora, a new genus of Polyzoa allied to the Graptolites; by J. W. Salter.

On the Fluctuations of Level in the North American Lakes; by Chas. Whittlesey.

Notice of the occurrence of Chrysolite in Basalt; by O. P. Hubbard.

On the occurrence of Sharks' Teeth in the Drift of the Mississippi; by A. H. Worthen.

A critical review of the different Measurements of Mount Washington, in the White Mountains of New Hampshire; by A. Guyot.

On the Physical Structure of the Continent of Africa; by A. Guyot.

On the General Distribution of Large Forests on the Globe as connected with certain Climatic conditions; by A. Guyot.

On the Direction of Ancient Currents of Deposition and the source of Materials in the Older Palæozoic Rocks, with Remarks on the Origin of the Appalachian Chain of Mountains; by James Hall.

On the Cretaceous formations of the United States and the North American Continent; by James Hall.

On the Carboniferous Limestones and Coal Measures of the United States; by James Hall.

On the comparative extent and distribution of the Limestones of the Palæozoic period, and the similarity of forms among fossils of the different epochs; with remarks upon the probability of different centres of distribution for the fauna of the same epoch; by James Hall.

Contributions to the Geology of California and the Gadsden Purchase: by T. Antisell.

On the occurrence of masses of Native Copper in the mineral veins of Point Keweenaw; by Chas. Whittlesey, Cleveland.

On the origin of Anthracite and Bituminous Coal; by C. Whittlesey.

Note on the Formation of Continents; by Benjamin Peirce.

Fossils of the Sandstones and Slates of North Carolina; by E. Emmons.

On the Age and Dip of the Connecticut River Sandstones, and the intercalation of the associated Trap; by Edward Hitchcock.

On Fractured Ledges of Slate in Vermont; by Charles H. Hitchcock.

Foot-Prints in the Texas Tertiary; by C. G. Forshey.

Explanations of the Geological Map of Missouri and a section of its Rocks; by G. C. Swallow.

Some observations on the Petrography of Gaston County, North Carolina; by Henry Wurtz.

New localities of Minerals observed in North and South Carolina, and especially upon the discovery of Nickel and Cobalt in quantity in Gaston County, North Carolina; by Henry Wurtz.

On the Parthenogenesis of Animals and Plants; by Berthold Seemann.

Marine Phosphorescence; by H. G. Warner, Rochester, N. Y.

On the functions of the Spinal Cord as manifested by experiments on cold-blooded Animals; showing that an animal is capable of perceptive movements after removal of the Cranium or Brain; by George Paton, M.D.

On the Structure of the Skull in Vertebrata; by T. C. Hilgard, M.D.

## III. *Ethnology, Statistics, Political Economy, etc.*

On Arrow-head or Wedge Inscriptions; by J. H. McIlvaine.

On the Ethnological Bearings of certain Architectural forms; by J. P. Lesley.

On the word Celt; by J. P. Lesley.

On a Universal Language; by Hugo Reid.

Thoughts on Species; by James D. Dana.

On the supposed Uniformity of Cranial Type throughout all varieties of the American Race; by Daniel Wilson, Toronto.

Remarks on the Collection of Indian Paintings and Antiquities exhibited by Mr. Paul Kane, at the request of the Local Committee; by Daniel Wilson.

Remarks on the Classification of the Varieties of Man; by M. B. Anderson.

On the ancient mining operations of Lake Superior; by Charles Whittlesey.

The Behistun Inscription (Arrow-head); by J. H. McIlvaine.

Observations upon the Sanscrit Language; by J. H. McIlvaine.

The Laws of Descent among the Iroquois.—1st, Descent in the Female Line.—2d, Degrees of Consanguinity; by L. H. Morgan.

Comparison of the Religious System of the Iroquois with that of the Ancient Persians; by L. H. Morgan.

On the Law of Human Mortality obtaining in Massachusetts, with Tables of Average duration of Life, Life Annuities, and other practical monetary values; by E. B. Elliot.

Intensity of Mortality at different ages in Massachusetts, England, Sweden, Prussia, Belgium, and other communities compared; by E. B. Elliot.

Observations on the Manners and Customs of the Indians of the North West; illustrated by paintings executed by the author during his travels; by Paul Kane.

On some Ethnological Specimens from the Island of Aneiteum, New Hebrides; by J. W. Dawson.

On certain peculiarities of the Languages of Southern Africa; by J. Constantine Adamson.

On Bank Notes, and the means adopted for prevention of counterfeiting; by B. Silliman, Jr., Yale College.

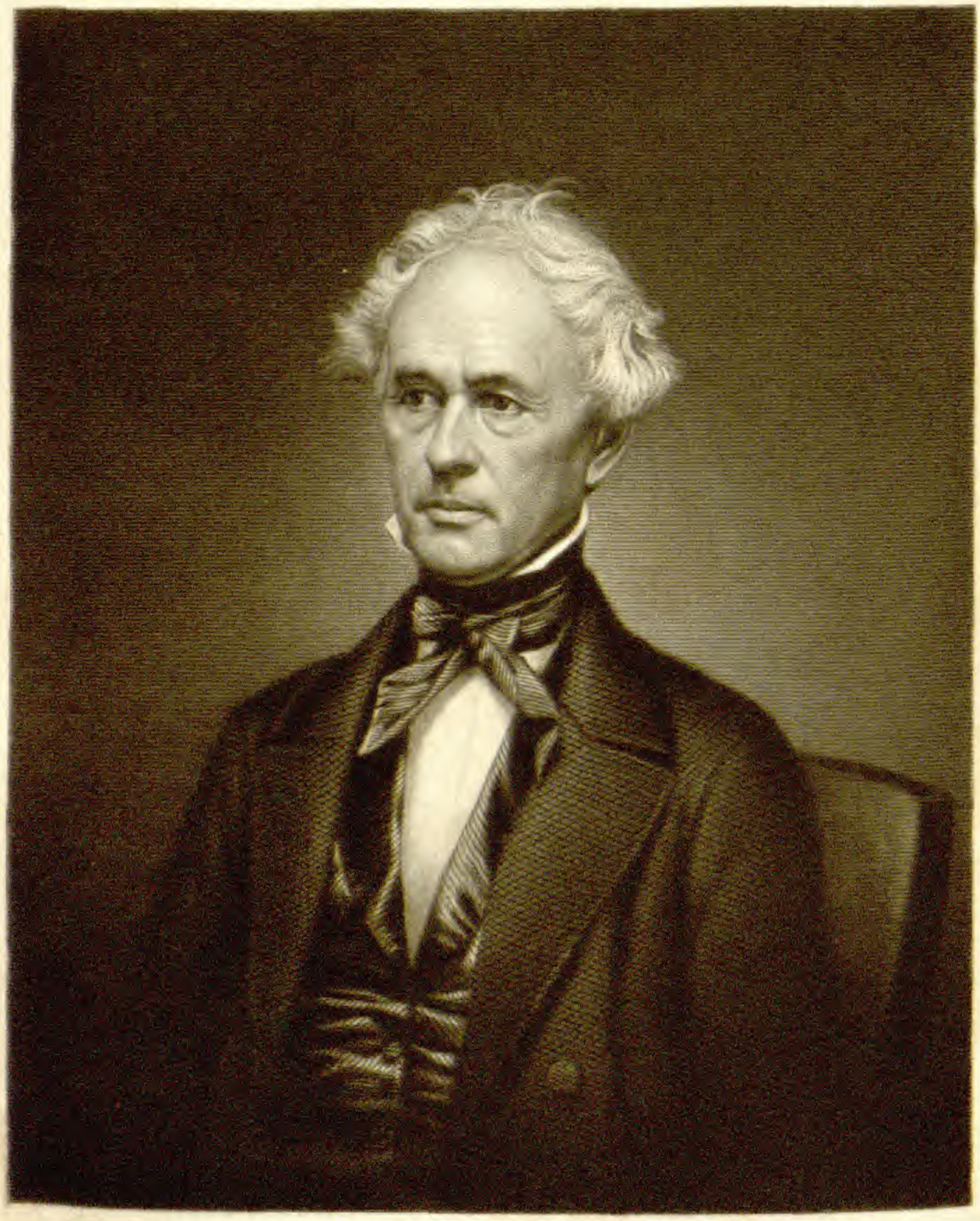
On some modes of preventing the Counterfeiting of Bank Notes; by T. S. Hunt.

On certain ternary compounds,—Chromites—recently discovered; by A. K. Eaton.

On Surety Paper; by E. N. Horsford.

Views and suggestions on the practice and theory of Scientific Publication; by Lieut. E. B. Hunt, Corps of Engineers, U.S.A.

The Universal Science; by Clinton Rosenvelt.



Engd for A.B. Rockwell

yours truly

Wm C. Redfield

THE

AMERICAN

# JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

---

## Art. XXII.—*Thoughts on Species;* by James D. Dana.

(Read before the American Association at Montreal, Aug. 13th, 1857.)

While direct investigation of individual objects in nature is the true method of ascertaining the laws and limits of species, we have another source of suggestion and authority in the comprehensive principles that pervade the universe. The source of doubt in this synthetic mode of reaching truth consists in our imperfect appreciation of universal law. But science has already searched deeply enough into the different departments of nature to harmonize many of the thoughts that are coming in from her wide limits; and it is well, as we go on in research, to compare the results of observations with these utterings of her universality.

I propose to present some thoughts on species from the latter point of view, reasoning from central principles to the circumferential, and, if I mistake not, we shall find the light from this direction sufficiently clear to illumine a subject which is yet involved in doubts and difficulties.

The questions before us at this time are—

1. What is a species?
2. Are species permanent?
3. What is the basis of variations in species?

1. *What is a species.*

It is common to define a species as *a group* comprising such individuals as are alike in *fundamental* qualities; and then by

way of elucidation, to explain what is meant by fundamental qualities. But the idea of a group is not essential; and moreover it tends to confuse the mind by bringing before it, in the outset, the endless diversities in individuals, and suggesting numberless questions that vary in answer for each kingdom, class, or subordinate group. It is better to approach the subject from a profounder point of view, search for the true idea of distinction among species, and then proceed onward to a consideration of the systems of variables.

Let us look first to *inorganic* nature. From the study of the inorganic world we learn that each element is represented by a specific amount or law of force; and we even set down in numbers the precise value of this force as regards one of the deepest of its qualities, chemical attraction. Taking the lightest element as a unit to measure others by, as to their weights in combination, oxygen stands in our books as 8; and it is precisely of this numerical value in its compounds: each molecule is an 8 in its chemical force or law, or some simple multiple of it. In the same way there is a specific number at the basis of other qualities. Whenever then the oxygen amount and kind of force was concentered in a molecule, in the act of creation, the species oxygen commenced to exist. And the making of many such molecules instead of one, was only a repetition in each molecule, of the idea of oxygen.

In combinations of the elements, as of oxygen and hydrogen, the resultant molecule is still equivalent to a fixed amount, condition, or law, of chemical force; and this law, which we express in numbers, is at the basis of our notion of the new species.

It is not necessarily a different amount of force; for it may be simply a different state of concentration or different rate or law of action. This should be kept in mind in connection with what follows.*

The essential idea of a species, thence deduced, is this: a *species* corresponds to *a specific amount or condition of concentered force, defined in the act or law of creation.*

Turn now to the organic world. The individual is involved in the germ-cell from which it proceeds. That cell possesses certain inherent qualities or powers, bearing a definite relation to external nature, so that, when having its appropriate nidus or surrounding conditions, it will grow, and develop out each organ and member to the completed result, and this, both as to all

* When we have in view, oxygen and the elements, we are apt to think of their molecules as distinguished by a different *amount* and *kind* of force. But when we consider the many different compounds that may be made of the same elements (as carbon and hydrogen), in the very *same* proportions, we are led to conceive of these as differing molecularly in a different *law* of the same force or forces. When, again, we see the same element under conditions as diverse as any two compounds, as in cases of allotropism, we are still better satisfied with adopting, for the present, the most general expression—a different law of action or condition of molecular force.

chemical changes, and the evolution of the structure which belongs to it as a subordinate to some kingdom, class, order, genus and species in nature. The germ-cell of an organic being develops a specific result; and like the molecule of oxygen, it must correspond to a measured quota or specific law of force. We cannot apply the measure, as in the inorganic kingdom, for we have learned no method or unit of comparison. But it must nevertheless be true, that a specific predetermined amount, or condition, or law, of force is an equivalent of every germ-cell in the kingdoms of life. I do not mean to say that there is but one kind of force; but that whatever the kind or kinds, it has a numerical value or law, although human arithmetic may never give it expressiou.

A species among living beings, then, as well as inorganic, is based on *a specific amount or condition of concentered force defined in the act or law of creation.*

Any one species has its specific value or law of force; another, its value; and so for all: and we perceive the fundamental notion of the distinction between species when we view them from this potential stand-point. The species, in any particular case, began its existence when the first germ-cell or individual was created; and if several germ-cells of equivalent force were created, or several individuals, each was but a repetition of the other: the species is in the potential nature of the individual, whether one or many individuals exist.

Now in organic beings,—unlike the inorganic,—there is a cycle of progress involving growth and decline. The oxygen molecule may be eternal as far as any thing in its nature goes. But the germ-cell is but an incipient state in a cycle of changes, and is not the same for two successive instants; and this cycle is such that it includes in its flow, a reproduction, after an interval, of a precise equivalent of the parent germ-cell. Thus an indefinite perpetuation of the germ-cell is in fact effected; yet it is not mere endless being, but like evolving like in an unlimited round. Hence, when individuals multiply from generation to generation, it is but a repetition of the primordial type-idea; and the true notion of the species is not in the resulting group, but in the idea or potential element which is at the basis of every individual of the group; that is, the specific law of force, alike in all, upon which the power of each as an existence and agent in nature depends. Dr. Morton presented nearly the same idea when he described a species as *a primordial organic form.*

Having reached this idea as the starting point in our notion of a species, we must still, in order to complete and perfect our view, consider what is the true expression of this potentiality. For this purpose, we should have again in mind, that a living cell, unlike an inorganic molecule, has only a historical existence.

The species is not the adult resultant of growth, nor the initial germ-cell, nor its condition at any other point; it comprises the whole history of the development. Each species has its own special mode of development as well as ultimate form or result, its serial unfolding, inworking and outflowing; so that the precise nature of the potentiality in each is expressed by the line of historical progress from the germ to the full expansion of its powers, and the realization of the end of its being. We comprehend the type-idea only when we understand the cycle of evolution through all its laws of progress, both as regards the living structure under development within, and its successive relations to the external world.

2. *Permanence of species.*

What now may we infer with regard to the permanence or fixedness of species from a general survey of nature?

Let us turn again to the inorganic world. Do we there find oxygen blending by indefinite shadings with hydrogen or with any other element? Is its combining number, its potential equivalent, a varying number,—usually 8, but at times 8 and a fraction, 9, and so on? Far from this, the number is as fixed as the universe. There are no indefinite blendings of elements. There are combinations by multiples or submultiples, but these prove the dominance and fixedness of the combining numbers.

But further than this, fixed numbers, definite in value and defiant of all destroying powers, are well known to characterize nature from its basement to its top-stone. We find them in combinations by volume as well as weight, that is, in all the relations of chemical attraction; in the mathematical forms of crystals and the simple ratios in their modifications,—evidence of a numerical basis to cohesive attraction; in the laws of light, heat, and sound. Indeed, the whole constitution of inorganic nature, and of our minds with reference to nature, as Professor Peirce has well illustrated, involves fixed numbers; and the universe is not only based on mathematics, but on finite determinate numbers in the very natures of all its elemental forces. Thus the temple of nature is made, we may say, of hewn and measured stones, so that, although reaching to the heavens, we may measure, and thus use the finite to rise toward the infinite.

This being true for inorganic nature, it is necessarily the law for all nature, for the ideas that pervade the universe are not ideas of contrariety but of unity and universality beneath and through diversity.

The units of the inorganic world, are the weighed elements and their definite compounds or their molecules. The units of the organic are *species*, which exhibit themselves in their simplest condition in the germ-cell state. The kingdoms of life in all their magnificent proportions are made from these units. Were

these units capable of blending with one another indefinitely, they would no longer be units, and species could not be recognized. The system of life would be a maze of complexities; and whatever its grandeur to a being that could comprehend the infinite, it would be unintelligible chaos to man. The very beauties that might charm the soul would tend to engender hopeless despair in the thoughtful mind, instead of supplying his aspirations with eternal and ever-expanding truth. It would be to man the temple of nature fused over its whole surface and through its structure, without a line the mind could measure or comprehend.

Looking to facts in nature, we see accordingly every where, that the purity of species has been guarded with great precision. It strikes us naturally with wonder, that even in senseless plants, without the emotional repugnance of instinct, and with reproductive organs that are all outside, the free winds being often the means of transmission, there should be rigid law sustained against intermixture. The supposed cases of perpetuated fertile hybridity are so exceedingly few as almost to condemn themselves, as no true examples of an abnormity so abhorrent to the system. They violate a principle so essential to the integrity of the plant-kingdom, and so opposed to nature's whole plan, that we rightly demand long and careful study before admitting the exceptions.

A few words will explain what is meant by perpetuated fertile hybridity. The following are the supposable grades of results from intermixture between two species:—

1. No issue whatever—the usual case in nature.
2. Mules (naming thus the issue) that are wholly infertile whether among themselves or in case of connection with the pure or original stock.
3. Mules that are wholly infertile among themselves, but may have issue for a generation or two by connection with one of the original stock.
4. Mules that are wholly infertile among themselves, but may have issue through indefinite generations by connection for each with an individual of the original stock.
5. Mules that are fertile among themselves through one or two generations.
6. Mules that are fertile among themselves through many generations.
7. Mules that are fertile among themselves through an indefinite number of generations.

The cases 1 to 5 are known to be established facts in nature; and each bears its testimony to the grand law of purity and permanence. The examples under the heads 2 to 5 become severally less and less numerous, and art must generally use an unnatural play of forces or arrangements to bring them about.

Again, in the animal kingdom, there is the same aversion in nature to intermixture, and it is emotional as well as physical. The supposed cases of fertile hybridity are fewer than among plants.

Moreover, in both kingdoms, if hybridity be begun, nature commences at once to purify herself as of an ulcer on the system. It is treated like a disease, and the energies of the species combine to throw it off. The short run of hybridity between the horse and the ass, species very closely related, reaching its end *in one single generation*, instead of favoring the idea that perpetuated fertile hybridity is possible, is a speaking protest against a principle that would ruin the system if allowed free scope.

The finiteness of nature in all her proportions, and the necessity of finiteness and fixedness for the very existence of a kingdom of life, or of human science its impress on finite mind, are hence strong arguments for the belief that hybridity cannot seriously trifle with the true units of nature, and at the best, can only make temporary variations.

It is fair to make the supposition that in case of a very close proximity of species, there might be a degree of fertile hybridity allowed; and that a closer and closer affinity *might* give a longer and longer range of fertility. But the case just now alluded to seems to cut the hypothesis short; and moreover it is not reasonable to attribute such indefiniteness to nature's outlines, for it is at variance with the spirit of her system.

Were such a case demonstrated by well-established facts, it would necessarily be admitted; and I would add, that investigations directed to this point are the most important that modern science can undertake. But until proved by arguments better than those drawn from domesticated animals, we may plead the general principle against the *possibilities* on the other side. If there is a law to be discovered, it is a wide and comprehensive law, for such are all nature's principles. Nature will teach it not in one corner of her system only, but more or less in every part. We have therefore a right to ask for well-defined facts, taken from the study of successive generations of the interbreeding of species known to be distinct.

Least of all should we expect that a law, which is so rigid among plants and the lower animals, should have its main exceptions in the highest class of the animal kingdom, and its most extravagant violations in the genus Homo; for if there are more than one species of Man, they have become in the main indefinite by intermixture. The very crown of the kingdom has been despoiled; for a kingdom in nature is perfect only as it retains all its original parts in their full symmetry, undefaced and unblurred. Man, by receiving a plastic body, in accordance with a law that species most capable of domestication should necessa-

rily be most pliant, was fitted to take the whole earth as his dominion, and live under every zone. And surely it would have been a very clumsy method of accomplishing the same result, to have made him of many species, all admitting of indefinite or nearly indefinite hybridization, in direct opposition to a grand principle elsewhere recognized in the organic kingdoms. It would have been using a process that produces impotence or nothing among animals for the perpetuation and progress of the human race.

There are other ways of accounting for the limited productiveness of the mulatto, without appealing to a distinction of species. There are causes, independent of mixture, which are making the Indian to melt away before the white man, the Sandwich Islander and all savage people to sink into the ground before the power and energy of higher intelligence. They disappear like plants beneath those of stronger root and growth, being depressed morally, intellectually and physically, contaminated by new vices, tainted variously by foreign disease, and dwindled in all their hopes and aims and means of progress, through an overshadowing race.

We have therefore reason to believe from man's fertile intermixture, that he is one in species; and that all organic species are divine appointments which cannot be obliterated, unless by annihilating the individuals representing the species.

It may be said, that different species in the inorganic world combine so as to form new units, and why may they not in the organic? It is true they combine, but not by indefinite blendings. There is a definite law of multiples, and this is the central idea in the system of inorganic nature. In organic nature, such a law of multiples, if existing, would be general, as in the inorganic; it would be an essential part of the system and should be easily verified, while, in fact, observation lends it no support, not even enough to have suggested the hypothesis.

In one kingdom, the *inorganic*, there is multiplication of kinds of units by combination, according to the law of multiples, and no reproduction; while in the *organic*, there is reproduction of like from like and no multiplication of kinds by combination. And thus the two departments of living and dead nature widely diverge.

Neither does the possibility of mere mixture among inorganic substances afford any analogy to sustain the idea of possible hybrid mixture indefinitely perpetuated, among living beings. The mechanical aggregation of units that make up ordinary mixture, is one thing; and the combination that would alter a germ, one of the units in organic species, even to its fundamental nature, is quite another. This last is not aggregation. It is as different from mere mixture as is chemical combination and stands somewhat in the same relation, so that the analogy has no bearing on the question.

3. *Variations of Species.*

But there are variations in species, and this is our next topic. The principles already considered teach, as we believe, that each species has its specific value as a unit, which is essentially permanent or indestructible by any natural source of change; and we have, therefore, to admit in the outset, if these principles are true, that variations have their limits, and cannot extend to the obliteration of the fundamental characteristics of a species.

To understand these variations, we may again appeal to general truths.

Variation is a characteristic of all things finite; and is involved in the very conditions of existence. No substance or body can be wholly independent of every or any other body in the universe. The most comprehensive and influential law in nature, most fundamental in all change, composition or decomposition, growth or decay, is the law of mutual sympathy, or tendency to equilibrium in force through universal action and reaction.

The planets have their orbits modified by other bodies in space through their changing relations to those bodies. A substance, as oxygen or iron, varies in temperature and state of expansion from the presence of a body of different temperature; in chemical tendencies from the presence of a luminous body like the sun; in magnetic or electrical attraction from surrounding magnetic or electrical influences. There is thus unceasing flow and unceasing change through the universe. All the natural forces are closely related as if a common family or group, and are in constant mutual interplay.

The degree or kind of variation has its specific law for each element; and in this law the specific nature of the element is in a degree expressed. There is to each body or species, the normal or fundamental force in which its very nature consists; and, in addition, the relations of this force to other bodies, or kinds, amounts or conditions of force, upon which its variations depend. One great end of inorganic science is to study out the law of variables for each element or species. For this law is as much a part of an idea of the species, as the fundamental potentiality; indeed the one is a measure of the other.

So again, a species in the *organic* kingdoms is subject to variations, and upon the same principle. Its very development depends on the appropriation of material around it, and on attending physical forces or conditions, all of which are variable through the whole of its history. Every chemical or molecular law in the universe is concerned in the growth,—the laws of heat, light, electricity, cohesion, etc.; and the progress of the developing germ, whatever its primal potentiality, is unavoidably subject to variations, from the diversified influences to which it may be exposed. The new germ, moreover, takes

peculiarities from the parent, or from the circumstances to which its ancestry had been exposed during one or more preceding generations.

There is then a fixed normal condition or value, and around it librations take place. There is a central or intrinsic law which prevents a species from being drawn off to its destruction by any external agency, while subject to greater or less variations under extrinsic forces.

Liability to variation is hence part of the law of a species; and we cannot be said to comprehend in any case the complete idea of the type until the relations to external forces are also known. The law of variables is as much an expression of the fundamental equalities of the species in organic as in inorganic nature; and it should be the great aim of science to investigate it for every species. It is a source of knowledge which will yet give us a deep insight into the fundamental laws of life. Variations are not to be arranged under the head of *accidents;* for there is nothing accidental in nature; what we so call, are expressions really of profound law, and often betray truth and law which we should otherwise never suspect.

This process of variation, is the external revealing the internal, through their sympathetic relations; it is the law of universal nature reacting on the law of a special nature, and compelling the latter to exhibit its qualities; it is a centre of force manifesting its potentiality, not in its own inner working, but in its outgoings among the equilibrating forces around, and thus offering us, through the known and physical, some measure of the vital within the germ. It is therefore one of the richest sources of truth open to our search.

The limits of variation, it may be difficult to define among species that have close relations. But being sure that there are limits,—that science, in looking for law and order written out in legible characters, is not in fruitless search, we need not despair of discovering them. The zoologist, gathering shells or mollusks from the coast of eastern America and that of Japan, after careful study, makes out his lists of identical species, with the full assurance that species are definite and stable existences; and he is even surprised with the identity of characters between the individuals of a species gathered from so remote localities. And as he sees zoological geography rising into one of the grandest of the sciences, his faith in species becomes identified with his faith in nature and all physical truth.

If then we may trust this argument from general truths to special,—general *truths* I say, for general principles as far as established are truths—we should conceive of a species from the potential point of view, and regard it as—

*a.* A concentered unit of force, an ineffaceable component of the system of nature; but

*b.* Subject to greater or less librations, according to the universal law of mutual reaction or sympathy among forces.

And, in addition, in the *organic* kingdom,

*c.* Exhibiting its potentiality not simply or wholly in any existing condition or action, but through a cycle of growth from the primal germ to maturity, when the new germ comes forth as a repetition of the first to go another round in the cycle and perpetuate the original unit; and, therefore, as follows from a necessary perpetuity of the cycle—

*d.* Exhibiting identity of species among individuals, by perpetuated fertile intermixture in all normal conditions, and non-identity by the impossibility of such intermixture, the rare cases of continuation for one or two generations, attesting to the stability of the law, by proving the effort of nature to rid herself of the abnormity, and her success in the effort.

*e.* The many like individuals that are conspecific do not properly constitute the species, but each is an expression of the species in its potentiality under some one phase of its variables; and to understand a species, we must know its law through all its cycle of growth, and its complete series of librations.

We should therefore conceive of the system of nature as involving, in its idea, a system of units, finite constituents at the basis of all things, each fixed in law; these units in inorganic nature as adding to their kinds by combinations in definite propositions; and those in organic nature adding to their numbers of representative individuals, but *not* kinds, by self-reproduction; and all adding to their varieties by mutual reaction or sympathy. Thus from the law within and the law without, under the Being above as the Author and sustainer of all law, the world has its diversity, the cosmos its fullness of beauty.

I would remark again that we must consider this mode of reaching truth, by reasoning from the general to the special, as requiring also its complement, direct observation, to give unwavering confidence to the mind; and we should therefore encourage research with a willingness to receive whatever results come from nature. We should give a high place in our estimate to all investigation tending to elucidate the variation or permanence of species, their mutability or immutability; and at the same time, in order that appearances may not deceive us, we should glance towards other departments of nature, remembering that all truth is harmonious, and comprehensive law the end of science.

A word further upon our conceptions of species as realities. In acquiring the first idea of species, we pass, by induction, as in other cases of generalization, from the special details displayed among individuals to a general notion of a unity of type; and

this general notion, when written out in words, we may take as an approximate formula of the species. One system of philosophy thence argues that this result of induction is nothing but a notion of the mind, and that species are but an imaginary product of logic; or at least, that since, as they say (we do not now discuss this point), genera are groupings without definite limits which may be laid off variously by different minds, so species are undefined, and individuals are the only realities—the supposed limits to species being regarded as proof of partial study, or a consequence of a partial development of the kingdoms of nature. Another system infers, on the contrary, that species are realities, and the general or type idea has, in some sense, a *real* existence. A third admits that species are essentially realities in nature, but claims that the general idea exists only as a result of logical induction.

The discussion in the preceding pages sustains most nearly the last view, that species are realities in the system of nature while manifest to us only in individuals; that is, they are so far real, that the idea for each is definite, even of mathematical strictness, (although not thus precise in our limited view,) it proceeding from the mathematical and finite basis of nature. They are the units fixed in the plan of creation; and individuals are the material expressions of those ideal units.

At the same time, we learn, that while species are realities in a most important and fundamental sense, no comprehensive type-idea of a species can be represented in any material or immaterial existence. For while a species has its constants, it has also its variables, each variable becoming a constant so far only as its law and limits of variation are fixed; and in the organic kingdoms, moreover, each individual has its historic phases, from the germ through the cycle of growth. The general idea sought out by induction, therefore, is not made up of *in*variables. Limited to these, it represents no object, class of objects, or law, in nature. The variables are a necessary complement to the invariables; and the complete species-idea is present to the mind, only when the image in view is seen to be ever changing along the lines of variables and development. Whatever individualized conception is entertained, it is evidently a conception of the species in one of its phases,—that is, under some one specific condition as to size, form, color, constitution, etc., as regards each part in the structure, from among the many variations in all these respects that are possible: mind can picture to itself individuals only and not species, and one phase at a time in the life of an organic individual, not the whole cycle.

We may attempt to reach what is called the typical form of a species, in order to make this the subject of a conception. But even within the closest range of what may be taken as typical

characters, there are still variables; and moreover, we repeat it, no one form, typical though we consider it, can be a full expression of the species, as long as variables are as much an essential part of its idea as constants. The advantage of fixing upon some one variety as the typical form of a species is this,—that the mind may have an initial term for the laws embraced under the idea of the species, or an assumed center of radiation for its variant series, so as more easily to comprehend those laws.

Again, abrupt transitions and not indefinite shadings have been shown to be the law of nature. In proceeding from special characters to a general species-idea, nature gives us help through her stepping stones and barriers. In former times, man looked at iron and other metals from the outside only, and searching out their differences of sensible characters, gradually eliminated the general notion of each, by the ordinary logical method of generalization. But science now brings the elements to the line and plummet, and reaches a fixed *number* for iron and other elements as to chemical combination, etc. By this means, the studying out of the idea of a species seems almost to have escaped from the domain of logic into that of direct trial by weights and measures. It is no longer the undefined progress of simple reason, with a mere notion at the end, but an appeal to definite measurable values, with stable numbers at bottom, fixed in the very foundations of the universe. So, in the organic kingdoms, where there is, to our limited minds, still greater indefiniteness in most characters, the barrier against hybridity appears to stand as a physical test of species. We are thus enabled in searching into the nature of a species, to strike from the outside detail to the foundation law.

The type-idea, as it presents itself to the mind, is no more a subject of defined conception than any mathematical expression. Could we put in mathematical terms the precise law, in all its comprehensiveness, which is at the basis of the species iron, as we can for one of its qualities, that of chemical attraction, this mathematical expression would stand as a representative of the species; and we might use it in calculations, precisely as we can use any mathematical term. So also, if we could write out in numbers the potential nature of an organic species, or of its germ, including the laws of its variables, this expression would be like any other term in the hands of a mathematician; the mind would receive the formula as an expression for the species, and might compare it with the formulas of other species. But, after all, we have here a mere mathematical abstraction, a symbol for an amount or law of force, which can be turned into conceptions, only by imagining (supposing this possible) the force in the course of its evolution of concrete realities, according to the law of development and laws of variations embraced within it.

ART. XXIII.—*Preliminary Researches on the alleged Influence of Solar Light on the Process of Combustion;* by JOHN LE CONTE, M.D., Professor of Natural Philosophy in the South Carolina College.

[Read before the "American Association for the Advancement of Science," at the Montreal meeting, August, 1857.]

A POPULAR opinion has long prevailed in England, and perhaps in other countries, that the admission of the light of the sun to an ordinary fire tends to *retard* the process of combustion. In some instances, the practice of placing screens before the fireplace, or of closing the shutters of the apartment, may be traced to the prevalent belief, that the access of sunlight to the burning materials is unfavorable to the continuance of the phenomenon of combustion. Most physical philosophers very naturally regard this opinion as a mere *popular prejudice;* probably originating in the well-known apparent dulling or obscuration of flames and of solid bodies in a state of ignition,—which takes place when they are exposed to strong light. The flame of a jet of burning hydrogen is scarcely visible in the diffused light of a clear day; that of an ordinary alcohol lamp is barely appreciable to the eye when exposed to the direct sunshine; while a portion of ignited charcoal which glows in the dark, appears to be extinguished when placed in the sunlight. These familiar phenomena, attributable to well-established physico-physiological laws, seem to afford a much more rational explanation of the origin of the popular opinion, than to suppose it to be based upon observations relating to the actual rapidity of burning.

About thirty-two years ago, Dr. Thomas M'Keever published a series of experiments in the "Annals of Philosophy,* which seemed to show, that there is a real foundation for the popular impression, and that solar light does actually retard the process of combustion. So far as I am aware, these remarkable experiments have never been repeated. Leopold Gmelin, in his "Hand-book of Chemistry,"† announces Dr. M'Keever's results without comment. The important bearing which they appear to have on the influence of solar light on chemical processes, as well as on the modern dynamical theory of the mutual convertibility of the so-called imponderables, induced me during the months of May and June last, to undertake a series of experiments with the view of testing the validity of Dr. M'Keever's

* Annals of Philosophy, New Series, vol. 10, p. 344, Nov. 1825.

† Leopold Gmelin's Hand-book of Chemistry, (Cavendish Society's Translation,) vol. 2, p. 35. London, 1849.—A contemporary journal, in noticing these results, remarks, "It has always been considered a vulgar error, that the sun's light extinguishes a fire, but the following experiments by Dr. M'Keever put the matter beyond a doubt." (Brewster's Edin. Journal of Science, vol. 5, p. 180. 1826.)

conclusions. The subjoined table will exhibit his results in a convenient form for future reference.

*Expt.* 1.—Green Wax Taper lost in 5 minutes

| In Dark, Temp. 67° | In Sunshine, Temp. 78° | Ratio. |
|---|---|---|
| 9·25 grs. | 8·5 grs. | 1 : 1·088 |

*Expt.* 2.—Taper Lost, by Burning 7 minutes, in

| Dark, Temp. 67° | Sunshine, Temp. 78° | Ratio. |
|---|---|---|
| 11 grs. | 10 grs. | 1 : 1·100 |

*Expt.* 3.—Mould Candle, to consume 1 inch took, in

| Dark, Temp. 68° | Sunshine, Temp. 80° | Ratio. |
|---|---|---|
| $56^m\ 0^s$ | $59^m\ 0^s$ | 1 : 1·053 |

*Expt.* 4.—Taper, to consume 1 inch took, in

| Dark, Temp. 67° | Sunshine, Temp. 79° | Ratio. |
|---|---|---|
| $4^m\ 30^s$ | $5^m\ 0^s$ | 1 : 1·111 |

*Expt.* 5.—Taper in Sunshine lost in 10 minutes

| In Painted Lantern. | In Uncoated Lantern. | Ratio. |
|---|---|---|
| 16·5 grs. | 15 grs. | 1 : 1·100 |

A *sixth* experiment, of a similar character, made in a strong *moonlight* indicated no such diminution in the rate of consumption.

The conclusion to which Dr. M'Keever came was, that solar light *does exercise* a positive retarding influence on the process of combustion. He supposes this effect to be owing to the well-known influence of the solar rays on many chemical processes:—in some instances accelerating them, but in others retarding them. Under this point of view, the *chemical rays* may be supposed to exercise a *deoxydizing* power, which, to some extent, interferes with the rapid oxydation of the combustible matter. In confirmation of this opinion, Dr. M'Keever made an experiment which appears to indicate that a taper burns more rapidly in the *red* than in the *violet* extremity of the solar spectrum.

In attempting a repetition of Dr. M'Keever's experiments, I found it impossible to secure that freedom from agitation in the atmosphere, during the exposure of the burning body to the influence of sunshine in the *open air*, which such an investigation demanded. This was his method of conducting the *first four* experiments given in the table. The powerful influence exercised by comparatively slight disturbances in the air, on the rapidity of combustion, renders attention to this circumstance of controlling importance. His method of obviating this difficulty by the use of lanterns, (as indicated in Experiment 5,) is objectionable, from the impossibility of securing precisely identical conditions in relation to the supply of air in the interior. There were, likewise, other considerations which urged me to modify his method of conducting the investigation. It occurred to me,

that, as in his experiments the *temperature* of the air which supplied oxygen for combustion in the sunshine, was about 12° Fah. above that in the darkened room, the *rarefaction* produced by heat might exercise some influence in retarding the rate of burning in the sunlight.

In conducting my experiments, I endeavored to secure *two conditions*, viz:

1. Absolute *calmness* in the atmosphere.
2. Exposure of the flame to the influence of intense solar light, *without heating the surrounding air*.

The *first* condition was secured, by performing *all* of the experiments in a large lecture-room, with all the doors and windows closed. To secure the *second* condition, I employed a portion of the apparatus belonging to a large solar microscope, consisting of the reflecting mirror, the condensing lens and tube, together with the mechanical arrangements for adjusting the direction of the light. As the condensing lens was upwards of four inches in diameter, I hoped to *exaggerate* enormously whatever effect the light might exert, by concentrating it on a comparatively small area. Inasmuch as the aperture in the window through which the light was admitted, was completely closed by this arrangement, the exterior agitations of the atmosphere were not felt in the room; while the pencil of light, thus thrown on the flame, traversed it, as well as the surrounding air, *without imparting a sensible amount of heat to the latter*.

I used the best *wax-candles*, (as they are called in the shops,) *four* to the pound, costing about 15 cents apiece.* By allowing them to burn a sufficient length of time to form a well-defined cup for the melted wax, and carefully turning the wicks so as to render them self-snuffing, the combustion was found to go on with remarkable uniformity in a calm atmosphere. The *rate of burning* was determined in the following manner:—A portion of candle, three or four inches in length, was secured to the bottom of one of the scale-pans of a tall balance and ignited; after allowing it to burn for ten or fifteen minutes, so as to secure a steady flame of constant size, it was *nearly* balanced by adding weights to the opposite scale-pan, allowing a slight preponderance to the candle-pan. In a short time the equilibrium was established by the burning of the candle;—the precise *time* at which the balance indicated a condition of equilibrium was *accurately noted*. Next, *a given* weight, (say 60 or 100 grains,) was withdrawn from the weight-pan, and the *time* of restoring the

* From the close approximation to *identity* in the rate of consumption, it is probable that these are the same as Dr. Ure's "genuine wax-candles." He found the consumption to be, "upon an average of many experiments, 125 grains per hour." (Dict. of Arts, Manuf. and Mines, 4th edition, Article, "Illumination, Cost of,") My experiments gave respectively, 136·7, 125·4, and 124·7 grains per hour. Other kinds of candles burn at a much more rapid rate.

equilibrium by the loss of weight in the burning candle, was, in like manner, recorded. In this manner, the rate of combustion was determined by observing the *time* occupied in consuming a *given weight* of the burning matter. The arrangements described above, enabled me to perform such experiments alternately in the darkened room, and in the concentrated sunbeam, *without moving* any portion of the apparatus in the room, and under external conditions as nearly identical as could be desired. Many preliminary experiments were made for the purpose of testing the delicacy of the arrangements, which very soon convinced me that no reliable results could be obtained unless the air was calm, and *also*, unless the candle was allowed to burn a *sufficient length of time* to establish *regularity* in the process of combustion. The days selected for the experiments, were perfectly *cloudless*. The state of the barometer and thermometer were carefully noted. I now regret that I neglected to record the hygrometric condition of the air. The cone of sunlight was so directed, that its *lower* margin illuminated the charred portion of the wick of the candle, while the *upper* boundary of the pencil traversed the flame near its apex. The following Table presents the results furnished by *three sets* of experiments performed on as many separate days.*

| Date. | Bar. reduced to 32° Fah. | Temp. of air, Fah. | Time of consuming 60 grains. | | Amount consumed in 10 minutes. | | Diff. grs. |
|---|---|---|---|---|---|---|---|
| | | | Dark. | Sunlight. | Dark. | Sunlight. | |
| May 9, | 29·92 | 67° | $26^m\ 24^s$ | $26^m\ 15^s$ | 22·73 grs. | 22·86 grs. | −0·13 |
| June 6, | 29·72 | 75°·5 | 28 39 | 28 45 | 20 94 " | 20·87 " | +0·07 |
| " 10, | 29 62 | 84° | 28 55 | 28 51 | 20·75 " | 20·80 " | −0·05 |

It will be observed, that these experiments indicate *no sensible difference* in the rate of combustion of the candle in the darkened room, and in the same apartment, with a pencil of concentrated sunlight directed on the flame; *provided*, the comparison is restricted to the results obtained on *any given day*. In two instances there was a slight *excess* in the rate of burning in the *sunshine*, and in the other, the excess was in favor of the *dark:* but the differences are probably within the limits of the experimental inaccuracies incident to such delicate investigations.

* The difficulty of keeping the pencil of solar light properly directed on a flame of *variable* altitude, induced me to try a "Burning Fluid" lamp having a short cylindrical reservoir, furnished with *two* wicks. The following results were obtained:

| Date. | Bar. | Temp. | Amount consumed in 10 minutes. | |
|---|---|---|---|---|
| June 3d, | 29·72 | 74° F. | Dark = 40·82 grains. | Sun = 40·00 grs. |
| " 4th, | 29·78 | 75° " | " = 40·95 " | " = 39·48 " |
| " 4th, | 29·78 | 75° " | " = 38·34 " | |
| " 4th, | 29·78 | 75° " | " = 37·52 " | |

The progressive *decrease* in the rate of combustion, as indicated by the experiments of the 4th of June, shows, that the variations in the *height of the liquid*, are sufficient to vitiate the results obtained from burning any *fluid material*.

These *negative results* are the more striking from the fact, that, if solar light exercised the decided influence on the process of combustion which Dr. M'Keever's experiments seem to indicate, we should expect the effects to be much more marked and conspicuous, when the light was increased in intensity from *eight to ten fold* by the concentration of a lens. The fact that the rays of the sun traversed the *glass lens* before they fell on the flame, can scarcely be urged as a possible explanation of the discrepancy; for Dr. M'Keever obtained analogous results when he employed *lanterns*. (Vide experiment No. 5.)

The obvious variation in the rapidity of combustion on *different days*, (as exhibited in my experiments,) illustrates in a most striking manner, the decided influence exercised on the process, by comparatively slight alterations in the external conditions. This fact should inspire us with wholesome caution, and check the spirit of rash generalization. Throwing out of consideration the possible fluctuations in the rate of burning arising from want of homogeneity in the combustible materials, and imperfections in the mechanical arrangements by which they are consumed, there are *three external conditions* which may be supposed to exercise more or less influence on the rapidity of the process. These are, *first*, barometric pressure; *second*, temperature of the air; and *third*, amount of aqueous vapor present. I propose to consider each of these separately.

### 1. *Barometric Pressure.*

From *à priori* considerations, we should be led to expect, that an increase of barometric pressure, through the consequent condensation of the air, would, *cæteris paribus*, tend to *augment* the rapidity of combustion, by furnishing the burning matter with a greater amount of oxygen in a given volume. Unfortunately, direct experiments are wanting to test this in as satisfactory a manner as we should desire. The older experiments in the Boylean vacuum, inasmuch as they relate to the degree of rarefaction at which combustion *ceased*, do not give us information in regard to the *rapidity* of the process at the various stages of exhaustion. The same remark applies to the later experiments of Grotthuss, as well as to the admirable "Researches" of Sir Humphry Davy on the "Effects of Rarefaction, by partly removing the Pressure of the atmosphere, upon Flame and Explosion."* The experiments of the latter show, that rarefaction produces striking alterations in the size and character of the flame, but do not touch the question of the relative *rate* of burning under different pressures:—they test the comparative *combustibility* of dif-

* Vide Davy's "Researches on Flame," Phil. Trans. for 1817, p. 45 et seq. Also, Works of Sir H. Davy, edited by Dr. John Davy. Vol. 6, p. 51 et seq. Lond. 1840.

ferent bodies, rather than the rapidity of consumption of a *given body* under various degrees of rarefaction. Nevertheless, Davy informs us, that he determined from actual experiment, that the amount of *heat* developed in a *given time* by combustion, is slowly *diminished* by rarefaction; "the diminution of the cooling power of the nitrogen, being apparently in a higher ratio than the diminution of the heating powers of the burning bodies." Speaking of the phenomena of combustion in *condensed* air, he says, "I ascertained, however, that both the light and *heat* of the flames of the taper, of sulphur and hydrogen, were increased by acting on them by air condensed four times; but not more than they would have been by an addition of $\frac{1}{5}$ of oxygen." Again, he says, "But by compression, there can be no doubt, the heat of flames from *pure* supporters and combustible matter may be greatly increased, probably in the ratio of their compression:"—in the case of air he does not think the effect would be so great. Inasmuch as the quantity of heat developed in a *given time* by the burning of a *given substance*, is known to be a measure of the amount of matter undergoing oxydation, we are justified in the inference, that the foregoing results of Sir H. Davy's experiments, show that the *rate* of combustion was retarded by the rarefaction and accelerated by the condensation of the air.

The most satisfactory results in relation to the influence of *condensed air* on the process of combustion, are those incidentally furnished about sixteen years ago, by M. Triger, a French civil engineer, during the operations necessary for working a bed of coal lying under the alluvium bordering the river Loire, near Languin in the department of *Maine-et-Loire*. In traversing an overlying stratum of quicksand from 59 to 65½ feet thick, he found it requisite to devise some means of excluding the semi-fluid quicksand and water, which found their way under every arrangement analogous to ordinary *cofferdams*, in such quantity as to defy all pumping operations intended to keep them dry. For this purpose, M. Triger employed large sheet-iron cylinders, about 3·39 feet in interior diameter, securely closed at the top, in which,—by means of a condensing pump incessantly worked by a steam-engine,—air was condensed to an amount sufficient to counteract the external hydrostatic pressure. The ingenious contrivance fully justified the expectations of the engineer; but the workmen were thus compelled to labor in air condensed under a pressure of about *three* atmospheres. Among other curious results of this state of things noticed by M. Triger, were the remarkable effects of condensed air on combustion. Much annoyance was at first experienced from the *rapid combustion* of the candles; which was only obviated by substituting flax for cotton threads in the wicks.* Similar phenomena were observed a few

* *Vide*, Comptes Rendus, Tome 13, p. 884, et seq., Paris, 1841. Also, Annales de Chimie et de Physique, 3d Series, Tome 3, p. 234, et seq., Paris, 1841.—The fol-

years ago, by the engineers of the Wilmington and Manchester railway, who employed analogous apparatus for securing the foundations for the piers of the railroad bridge across the Great Pee Dee river in South Carolina. So far as I have been able to ascertain, the results manifested in this case, were identical with those recorded by M. Triger, and afford a most striking confirmation of the influence of condensed air in *accelerating* the process of combustion.

On the other hand, facts are not wanting to prove, that combustion is *retarded* at considerable elevations above the ocean, where the air is rarefied by diminished pressure. In a letter recently communicated to the Royal Society of London, from J. Mitchell, Esq., Quartermaster of artillery at Bangalore, India, "On the Influence of Local Altitude on the Burning of the Fuses of Shells;" this officer shows, that there was a *progressive retardation* of the rate of combustion of the fuses, at altitudes of 3000, 6500, and 7300 feet, as contrasted with the rapidity of burning at the Artillery Depot yard. This difference, Mr. Mitchell, very rationally, attributes, "to the rarity of the atmospheric air, and of its constituent oxygen, at the higher stations."* The following table,—in which I have reduced the barometric heights to the *freezing point*,—exhibits the *mean results* of his experiments.

| Height in Feet. | Bar. at 32° F. | Temp. Fahr. | Average Time of Burning 3 inches of Fuse. | No. of Expts. |
|---|---|---|---|---|
| Depôt. | 29·610 | 89° | 14·25 seconds. | 6 |
| 3000 feet. | 26·755 | 82° | 15·78 " | 5 |
| 6500 " | 23·951 | 61°·8 | 17·10 " | 3 |
| 7300 " | 22·979 | 54°·2 | 18·125 " | 2 |

These experiments seem to have been made with great care; all in the presence of artillery officers, who were furnished with the most accurate methods of measuring time. They amply prove the fact, that combustion is retarded at considerable elevations.

Thus, a variety of well-established facts, concur in fortifying the conclusions to which we are led by *à priori* reasoning; *namely*, that the process of combustion is *retarded* by diminution of the density of the air, while it is *accelerated* by its condensation. It has long been a matter of common observation, that ordinary wood-fires burn more freely when the barometer is high; but, Mr. Marcus Bull and others maintain,† that this result is not

lowing are the words of M. Triger, "A la pression de trois atmosphères, cette accélération devient telle que nous avons été obligés de renoncer aux chandelles à mèches de coton pour les remplacer par des chandelles à mèches de fil. Les premiéres brûlaient avec une telle rapidité, qu'elles duraient à peine un quart d'heure, et elles rèpandaient en outre une fumée intolérable."

* Philosophical Magazine, 4th Series, vol. 10, p. 48, July, 1855. Fuses burn *without air;* but the *rate* of burning is influenced by atmospheric oxygen.

† *Vide*, Trans. of Am. Philosophical Society, 2d Series, vol. 3, p. 55–56.—Philadelphia, 1830.

owing to the augmented *density* of the air, but to the greater *dryness* of the atmosphere. The facts brought forward in this paper, are strongly opposed to this explanation; for, there are not the slighest grounds for supposing, that there was *less* than the ordinary amount of aqueous vapor present in the condensing cylinders of M. Triger; or *more* than the usual quantity mixed with the air at the elevated stations in India. On the contrary, physical considerations lead us to precisely *opposite* conclusions.

### 2. *Temperature of the Air.*

In relation to the influence of the *temperature* of the air on the *rate* of combustion, our information is still more meagre. The experiments of Grotthuss and Sir H. Davy on the "Effects of Rarefaction by Heat on Combustion and Explosion," give contradictory results:* but, as they relate exclusively to the influence of temperature on the *ignition* of explosive mixtures of gases, they test its effects on *combustibility*, and are obviously inapplicable to the question under consideration. The well-known effects of the "Hot Blast" in increasing the temperature of furnaces, cannot be applied as a test of the influence of warm air on the rate of combustion under ordinary circumstances. *First*, because the air of the "hot blast" is *not* in its natural state of *density;* and *secondly*, because the augmentation of temperature observed in such cases, probably arises from its greater *availability*, growing out of the fact, that less heat is carried off in the products of combustion, rather than an absolute increase in the *rapidity* of burning.

In the absence of direct experimental evidence, it may be admissible to apply general reasoning based upon well-known physical principles. So far as an increase of temperature influences the *density* of the air, it is sufficiently evident, that its effect must be equivalent to a diminution of barometric pressure; and, consequently, must tend to *retard* the process of combustion. Assuming the temperature of the flame to be *constant*, it is likewise plain, that the *draught* created by it,—depending, as it is known, on the *difference* of temperature between the flame and that of the surrounding air,—must be *diminished* in a warm atmosphere; and, therefore, also tend to *retard* the rate of combustion, *cæteris paribus*, during hot seasons. But inasmuch as the variations in the velocity of the draught, are proportional to the *square roots* of these differences of temperature, it is obvious, that its effects must be insignificant under ordinary fluctuations of atmospheric temperature. For example, supposing the temperature of the flame to be 1500° Fahr., then the fluctuation of the draught between the temperatures of 80° and 60° Fahr., would

* Phil. Trans., for 1817, p. 53.

be in the ratio of $\sqrt{1500-80} : \sqrt{1500-60} = \sqrt{1420} : \sqrt{1440} = 1 : 1{\cdot}0070$. When, however, the comparison is made between bodies burning in summer and in winter, the influence from this cause will be more sensible, and ought not to be entirely overlooked.*

On the contrary, it is *possible*, that an augmentation of temperature might tend to *accelerate* the process of combustion, by favoring the liquefaction of the wax, and, perhaps, facilitating the oxydation of the combustible matter. If any such influence is exercised, it is probable, however, that its effect must be inappreciable under ordinary circumstances. Under this view of the subject, the only obvious influence which atmospheric heat exercises on the rapidity of combustion, is connected with its effects on the *density* of the air: and that, consequently, an increase of temperature should, *cæteris paribus*, *retard* combustion, and *vice versa*.

### 3. *Amount of Aqueous Vapor present.*

Sir Humphry Davy found that "a very large quantity" of *steam* was required to prevent sulphur from burning; that an explosive mixture of oxygen and hydrogen, when mixed with 5 *times its volume of steam*, still exploded by the electric spark; and that a mixture of air and carburetted hydrogen gas, required "a *third* of steam to prevent its explosion, whereas $\frac{1}{5}$ of azote produced the effect."† Under any point of view, it is obvious, that the presence of aqueous vapor can only tend to *retard* the process of combustion. *First*, because it diminishes the amount of oxygen in a given volume of air, and *secondly*, because an admixture of any inactive gas tends to extinguish the burning body, as is abundantly proved by the experiments of Sir H. Davy and others. When vapor is present in large quantities, there can be no doubt of its controlling agency on combustion. This is illustrated by the successful application of the plan proposed by M. Dujardin of Lille, in 1837, for extinguishing fires occurring in steam-ships, by permitting the steam from the boilers to escape into the apartment in which the combustion originates.‡ But experiments are still wanting, for determining its influence on the rate of burning, when existing in the small quantities in which it is usually associated with the atmosphere.§ The exper-

* I endeavored to test the influence of *temperature* on the rate of combustion, by placing the burning candle over a *large heated plate;* but,—as might have been expected,—the *unsteadiness of the flame* rendered the experiment unsatisfactory.

† Phil. Trans. for 1817, p. 65.

‡ Comptes Rendus, Tome 5, p. 28. Paris, 1837: also, Tome 35, p. 368, et 706. Paris, 1852.

§ The curious results obtained by Mr. J. F. Dana, and subsequently Mr. Samuel Morey, in relation to increasing the *brightness* of the flames of highly carbonaceous combustibles, by throwing a jet of steam into them, are obviously inapplicable to candles. (*Vide*, Silliman's Journal, 1st Series, vol. 1, p. 401; vol. 2, p. 118, 122; and vol. 7, p. 141.)

imental researches of Mr. David Waldie, in relation to the mixture of various gases with air, led him to the *general law*, that, "Of incombustible gases which remain undecomposed, the power of preventing combustion is in the order of their density:" and that, "This effect of density in cooling the flame depends on the excessive *diffusion* of the flame in the denser gas."* Under ordinary circumstances, the *density* of the aqueous vapor existing in the air is comparatively *small*, so that, according to Mr. Waldie's law, its influence on combustion ought not to be very striking. It is very desirable that this point should be submitted to a more rigorous experimental investigation.

Having discussed the probable influence of the *three external conditions* on the rate of combustion, we are, in a measure, prepared to investigate their *adequacy* to explain the variations in the *rapidity of burning*, as indicated by the experiments which I have brought forward. In *none* of them, have we the observations necessary for ascertaining the *hygrometric condition* of the atmosphere: this must, therefore, be thrown out of consideration. In Dr. M'Keever's experiments, the *barometric* indications are *not* given; neither is it known how many of them were performed on any *one day*. In my experiments, as well as in those of Mr. Mitchell, we are furnished with the data requisite for estimating the *combined* influence of *pressure and temperature*. Assuming, with Sir H. Davy, that the *rapidity* of combustion is in the *direct ratio of the density of the air*, we may submit these two effects to a *quantitative* estimation, by using Mariotte's law and Regnault's coëfficient of expansion for air.

1. Presuming that *each set* of experiments made by Dr. M'Keever, alternately in the dark and in the sunshine, were performed on the *same day*, and therefore under *identical* barometric conditions, we may form some estimate of the adequacy of *temperature* to account for the difference in the rate of burning observed by him. The subjoined table, which I have constructed from the data previously given, will place this in a clear light.

| Expt. | Temp. Dark. | Temp. Sun. | Consumed in 10 minutes, in Dark. | Consumed in 10 minutes, in Sun. | Ratio of Amt. in Sun & Dark. | Ratio of *Den.* Air in Sun & Dark. |
|---|---|---|---|---|---|---|
| No. 1, | 67° F. | 78° F. | 18·50 grs. | 17·00 grs. | 1 : 1·088 | 1 : 1·021 |
| No. 2, | 67° " | 78° " | 15·72 " | 14·29 " | 1 : 1·100 | 1 : 1 021 |
| No. 3, | 68° " | 80° " | | | 1 : 1 053 | 1 : 1·023 |
| No. 4, | 67° " | 79° " | | | 1 : 1·111 | 1 : 1·023 |

The remarkable discrepancies indicated by the numbers in the first column of *ratios*, afford a striking illustration of the existence of some disturbing cause, tending to vitiate the accuracy of these experiments. But a glance at the numbers contained in the two columns of *ratios*, is sufficient to show, that *temperature alone* is entirely *inadequate* to account for the diminished rate

* *Vide*, Philosophical Magazine, 3d Series, vol. 13, p. 86, et seq. August, 1838.

of combustion in the sunshine. A remarkable difference is observed in the *rate* of consumption in experiments 1 and 2. Number 1 was made with a "green wax taper," and No. 2 with a "taper;" but, as from the context, the *second* experiment appears to be a repetition of the *first*, the presumption is, that the same kind of taper was used in both cases. The rate of burning in experiments Nos. 3 and 4, was determined by the *time* required to consume a *given length;* and as one of them was made with a mould-candle and the other with a taper, no comparison can be extended to them, so far as the rates of consumption in these two cases are concerned. The irregularities exhibited in these results, probably arose from the agitations of the atmosphere, which were incident to the method of exposing the burning body to the sunshine in the *open air*. As the *excess* of the consumption in the dark, varied from 5 to 11 per cent, whereas the excess in the density of the air was only 2·3 per cent, it is evident, that some *other* cause than *temperature* must be evoked to explain the difference.

2. In my experiments, the conditions were such as to eliminate the effects of *temperature* on the results obtained in the dark and in the sunshine, on any *given day;* and it has been shown, that for *each pair* of experiments thus conducted, the variations in rate of combustion *do not* exceed the probable limits of experimental error. In this case, therefore, the question to be determined is, whether the differences in the *rapidity of burning* observed on *different days*, can be explained by the variations of the barometer and thermometer? For this purpose, I shall take the *average* of each *pair* of experiments, as a nearer approximation to the correct rate of burning on each of the three days. The following table, in which the *relative densities* of the air have been calculated, by *combining* the effects of barometric and thermometric oscillations, will serve to illustrate this point.*

| Ratio of Consumption. | Ratio of Density of Air. | Diff. |
|---|---|---|
| In exp't 1 & 2=1 : 1·0904 | 1 : 1·0230 | +6·74 per cent. |
| " " 2 & 3=1 : 1·0063 | 1 : 1·0193 | −1·30 " |
| " " 1 & 3=1 : 1·0967 | 1 : 1·0428 | +5·39 " |

It will be seen, that the rate of combustion increases in a decidedly *higher ratio* than the *density* of the air. If, therefore, we assume that the rapidity of burning is, *cæteris paribus*, in the direct ratio of the density of the air, it follows, that some *other agency* must have coöperated in these cases.

* In making these calculations, I used the following formula, based upon the two well-known physical laws, that the *density* of any permanent gas, varies *directly* as the compressing force, and *inversely* as the volume:

$$d : d' :: \frac{b}{1+0{\cdot}002036(t-32)} : \frac{b'}{1+0{\cdot}002036(t'-32)};$$

in which $d$ and $d'$ represent the *densities;* $b$ and $b'$ the *barometric heights* reduced to the freezing point; and $t$ and $t'$ the *temperatures* on Fahrenheit's scale.

3. The results of Mr. Mitchell's experiments at different altitudes, may, in like manner, be subjected to a similar numerical test. The subjoined table is constructed from the data contained in that which is given on a previous page.

| Ratio of Rate of Burning. | Ratio of Density of Air. | Diff. |
|---|---|---|
| In exp'ts 1 & 2 = 1 : 1·1074 | 1 : 1·0926 | +1·48 per cent. |
| " " 2 & 3 = 1 : 1·0836 | 1 : 1·0755 | +0·81 " |
| " " 3 & 4 = 1 : 1·0599 | 1 : 1·0270 | +3·29 " |
| " " 1 & 3 = 1 : 1·2000 | 1 : 1·1751 | +2·49 " |
| " " 2 & 4 = 1 : 1·1486 | 1 : 1·1045 | +4·41 " |
| " " 1 & 4 = 1 : 1·2719 | 1 : 1·2068 | +6·51 " |

This comparison places in a still stronger light the fact that the augmentation in the rate of burning, increases in a somewhat *higher ratio than the density of the air;* while at the same time, it clearly demonstrates the *controlling influence of atmospheric density* on the phenomenon of combustion. The *extreme rates* of burning are as the numbers 100 to 127, while the corresponding *densities* of the air are as 100 to 121, nearly; in the other cases the approximation to *identity* in the ratios is still closer. Would the variations in the hygrometric state of the atmosphere, which we have left out of consideration, explain this discrepancy? In the absence of the experiments necessary for testing this question, it would be premature to hazard any conjecture. I may remark, however, that in the case of Mr. Mitchell's experiments, the correction for the effects of aqueous vapor would, probably, *in one point of view*, operate in the *wrong direction*, and thus tend to increase the discrepancy in the ratios. For as the temperature was decidedly *higher* at the lower stations, it is more than probable that the *tension of vapor* was *greater* there than at the upper ones; and, consequently, that its influence in retarding combustion should be *relatively greater* at the points nearer the sea-level. This, of course, would tend to *equalize* the rates of burning at lower and higher altitudes, when no correction is made for this cause. On the contrary, it is obvious that the influence of vapor having a *given tension* in altering the relative amount of air in a *given volume*, must be *greater* when the barometer is low. From this cause the aqueous vapor at the upper stations might have had a *greater* effect in retarding combustion, and thus tended to *exaggerate* the difference in the rates of burning.

The comparatively large rate of consumption indicated by my *first* experiment of the 9th of May, (being more than nine per cent above the others,) was most probably attributable to a combination of causes. All of the *three external conditions* concurred in accelerating the process. The barometer was *high*, the temperature *low*, and the atmosphere *excessively dry*. The last-mentioned condition was accidentally forced upon my attention from

the fact that on that day I failed in an experiment for determining the dew-point by means of Daniell's hygrometer.*

From the foregoing discussion it is evident that the subject demands a thorough experimental investigation, with a minute at-

* Collaterally related to this subject are the effects of condensed and rarefied air and of temperature on the *process of respiration and the elimination of carbonic acid* in men and other warm-blooded animals. M. Legallois found that when warm-blooded animals breathed air under *pressure* reduced to 11·811 inches, the amount of oxygen consumed was *diminished.* (Ann. de Chemie et de Phys., tome 4, p. 113, 1817.) M. Théodore Junod's experiments show that *condensed air* produced deep inspirations and an agreeable glow throughout the system; while *rarefied air* had an opposite effect. (Archives Générales de Médecine, 2d series, tome 9, p. 157. Paris, 1835. Also, Magendie's Report on the same Memoir, Comptes Rendus, tome 1, p. 60. Paris, 1835.) The observations of M. Triger, already referred to, indicate analogous effects on those who labored in the condensed air. They could do double work without fatigue, and even old asthmatics seemed to recover their vigor. (Comptes Rendus, tome 13, p. 884, et seq. Paris, 1841.) M. Vierordt tested the effects of barometric pressure between 29·309 and 30·197 inches. The *average* rise of 0·5036 of an inch,

| | | | | | |
|---|---|---|---|---|---|
| *Increased* the air expired | | 35·746 | cub. inches | per | minute. |
| " " No. of respirations | | 0·74 | " | " | " |
| " " " " pulse | | 1·30 | " | " | " |

Dr. Hutchinson found that in a mine 1488 feet deep, where the pressure was 1·54 inches more than at the sea-level, the respiration was *increased* 2·4 per minute, and the pulse 1·3 per minute.(Cyc. of Anat. et Physiol. [article Respiration], vol. 4, p. 348–349. Lond., 1852.)

Analogous effects are produced by *temperature.* In the famous experiments of Séguin and Lavoisier, at 82° Fahr., the former (fasting and at rest) consumed 1210 French cubic inches of oxygen per hour; whereas at 57°, he consumed 1344 cubic inches per hour. (Mémoires de l'Acad. Royale, for 1789.) Dr. Crawford found, that a Guinea pig at 55°·5 F. abstracted *twice* as much oxygen from the air as at 104° F. (Exp'ts and Obs. on Animal Heat, 2d ed., p. 311–315. Lond., 1788.) Dr. W. F. Edwards found that birds consume more oxygen in winter than in summer. (De l'Influence des Agens Physiques sur la Vie, chap. 6, p. 195. Paris, 1824.) The best experiments are those of M. Vierordt. (*Op. cit. supra.*) He obtained the following results between 37°·4 and 75°·2 Fahr.

| | Av. Temp. 47°·24. | Av. Temp. 66°·92. | Diff. |
|---|---|---|---|
| Pulse per minute, | 72·93 | 71·29 | 1·64 |
| Respiration per minute, | 12·16 | 11·57 | 0·59 |
| Vol. of Air exp'd per minute in cub. inches, | 407·00 | 367·00 | 40·00 |
| " " $CO_2$ " " " " " " | 18·25 | 15·72 | 2·53 |

M. Felix Letellier's experiments on warm-blooded animals confirm these results. He found the amount of *carbonic acid* evolved *per hour* at different temperatures, to be as follows:

| | 86° to 104° F. | 59° to 68° F. | 32° F. |
|---|---|---|---|
| Canary, | 0·129 grammes. | 0·250 grammes. | 0·325 grammes. |
| Pigeon, | 0·366 " | 0·684 " | 0·974 " |
| Two Mice, | 0·268 " | 0·498 " | 0·531 " |
| Guinea Pig, | 1·453 " | 2·080 " | 3·006 " |

(*Vide* Comptes Rendus, tome 20, p. 795. Paris, 1845. Also, Ann. de Chemie et de Phys., 3d series, tome 13, p. 478. Paris, 1845.) Doubtless *physiological reactions* exercise a powerful influence over the results of such experiments; nevertheless, as respiration is *essentially* a process of combustion, they have a *general bearing* on the question under consideration.

tention to all of the external conditions which may influence the results. This I propose to undertake during the next twelve months. In the mean time it is hoped that these preliminary researches may prepare the way for a clearer appreciation of the difficulties which are to be encountered. Perhaps, however, in the present stage, we may be warranted in deducing *two* conclusions: 1st, that *solar light does not* seem to exercise any sensible influence on the process of combustion; and 2dly, that variations in the *density of the air do exert* a striking effect in retarding or accelerating the rapidity of the process, the rate of burning augmenting with every increment of density and *vice versa;* but the exact ratio between them remains to be determined.

Columbia, S. C., June, 1857.

---

ART. XXIV.—*Researches upon the Influence of Sulphur upon Iron and that of Phosphorus in partially neutralizing the action of the Sulphur;* by M. JANOYER.

(Translated from the Ann. des Mines, 6th vol., for 1854, p. 149, for the Amer. Jour. of Science and Arts, by W. J. TAYLOR.)

THE deleterious influence of sulphur upon the qualities of the various kinds of iron is a fact known to all persons engaged in metallurgy. Indeed, it is well understood that there is a very great difference between the irons manufactured with charcoal and those with mineral coal. These last are nearly all more or less "hot-short," although made from the purest ores. This bad quality of the iron is to be attributed generally to the presence of the sulphur in the mineral coal. Traces of sulphur that can scarcely be detected by analysis, are sufficient to render the iron "hot-short." Such irons, treated in the cold, are soft and tenacious; they are generally wanting in lustre in the fracture, and are welded with great difficulty; on the contrary, they are very brittle when hot, especially at a cherry-red heat, from which fact they have received the name of "fers de couleur."

According to Karsten (Manuel de Metallurgie), 0·03375 per cent of sulphur is sufficient to destroy the property of welding in the iron and to render it completely "hot-short." The latest analyses of the hot-short irons afford only one part of sulphur in 10,000 parts of iron.

The experiments made on this subject by this able metallurgist were carried out with great care. I will mention one operation on a great scale, which sustains his statement, that the process by which the iron receives the sulphur and which therefore is especially to be avoided, is the fusion of the ore in contact with the combustible mineral in the high furnace.

During the year 1850, I treated in the high furnace of L'Orme (Loire) only the ore from Privas (Ardèche), of which I have given the analysis (Annales des Mines, t. xx, 1855). This ore is a hematite (anhydrous sesquioxyd of iron), with shining lustre, unctuous to the touch, leaving upon the fingers a greasy coating of a red color. It is very pure, and of course well adapted to make iron of excellent quality. As evidence, it will be sufficient to consult the excellent memoir by M. Gruner, Ingenieur in chef, des Mines, "On the ores of Privas and Lavoutte," (Ann. des Mines, 3e Serie). From pages 374 and 375 of this memoir the following analyses are taken, proving the purity of the Privas ores.

| | Rich ores. | | Average ores. |
|---|---|---|---|
| Sesquioxyd of iron, | 83·9 | | 60·2 |
| Alumina, | 0·8 | | — |
| Carbonate of lime, | 7·4 | Carb. lime, Mag., &c. | 29·6 |
| Silica and clay, | 6·5 | | 7·0 |
| Water, | 1·2 | Water and bitum. | 3·2 |
| Oxyd of manganese, | trace | | — |
| | 99·8 | | 100·0 |

According to the author, this ore contains scarcely a perceptible trace of sulphur and phosphorus. On page 376 he says, "Sulphur has in vain been sought for, and only the slightest trace of phosphorus has been detected. I ought therefore, from the purity of the ores, to obtain an iron superior to any made in the neighborhood. Notwithstanding this, the iron afforded was moderately "hot-short." It presented, when cold, all the qualities of the best iron; soft, with black fibres and without grain; it could be bent and twisted in every way without producing a flaw. On the contrary, at a cherry-red heat it was very brittle and had lost all its tenacity.

The gangue of the ore was then assayed to determine if it contained barytes, for it is known often to occur with this kind of ore. * * * The experiments proved that sulphate of baryta did not exist in the gangue. The following are the results of two complete analyses of the ore in which all these researches for sulphur were made:

| | Ore (Agatisé). | Rich and laminated. |
|---|---|---|
| Volatile matters, | 1·4 | 6·4 |
| Silica, | 11·0 | 12·4 |
| Sesquioxyd of iron, | 82·0 | 74·0 |
| Alumina, | 1·6 | 1·0 |
| Lime, | 3·6 | 6·0 |
| Manganese, Sulphur, | none | none |

It will be seen from the above that the "hot-short" property of the iron was not owing to the sulphur contained in the ore. It can therefore result only from the sulphids contained in the coke with which it was fused. The coke used in these experiments was invariably that of Peronnière, near Rive-de-Gier

(Loire), the analyses of which (Annales des Mines, 1851, t. xx), afforded 0·28 per cent of sulphur.

The combustible material consumed at this time amounted to 22,000 kilograms (57,200 ℔s.) every twenty-four hours; introducing into the furnace in this space of time 61ᵏ·600 of sulphur (160 ℔s.), which, according to a preceding memoir, is only able to go from the high furnaces as a proto-sulphid in the iron, or in the state of sulphide of calcium in the slags. These last being slightly silicious, the cast iron contained the principal portion of the sulphur.

It was therefore by no means impossible that this quantity should exert, in the high furnace, a very pernicious influence on the product, the cast iron obtained containing 0·003 per cent of sulphur (the yield being 20,000 kilogrammes every twenty-four hours, and supposing, which was not the case, that all the sulphur passed into the cast iron). This protosulphid of iron formed in the metal, should be found from its stability in the wrought iron produced, so that there will then be more than sufficient sulphur to render the iron very "hot-short."

The objection may be made that the sulphur might have been introduced during the transformation of the cast into wrought iron during the puddling in the presence of coal containing much pyrites, which permits a disengagement of half its sulphur at a red heat.

But I say still that the passage of sulphur into the iron certainly takes place in the fusion of the ore in contact with the coke in the furnace stack. For at this time the same ore from Privas was treated in the same high furnace with charcoal, and under the same very careful conditions which were used in fusing the same with coke. The slags were entirely siliceous, like those obtained in the experiments with the mineral coal, which would favor the complete passage of the sulphur into the cast iron by preventing it from escaping as a sulphid of calcium, in the slags. The slag contained Silica 53·77, alumina 17·93,* lime 28·30=100. * * *

The lime was found to be entirely taken up by the silica and consequently could have no affinity for the sulphur. Notwithstanding, the cast iron obtained, puddled in the same furnaces with sand and coal,† by the same workmen, and under exactly the same conditions, gave an iron which presented in all points the characters of the best iron; its tenacity was perfect at all temperatures, presenting none of the characters of a brittle iron at a cherry-red heat.

* The protoxyd of iron, owing to its small quantity, was not separated from the alumina.

† The coal employed came from the mine Du Bois d'Aveize, concession de Terre Noire. It is classified and described by M. Gruner in his memoir (Annales des Mines, t. II, 5ᵉ série, p. 166).

Independent of the influence of the sulphur in coke, this experiment shows that it is important to demonstrate a fact practically: the action of sulphur, as will be clearly perceived, was in the fusion of the ore in contact with the combustible mineral, and *not* in the transformation of the cast iron into wrought iron by puddling.

It may hence be concluded that the sulphurous acid disengaged from the coal upon the grate of the puddling furnace and in reheating has no sensible effect on the iron. The sulphid which may be formed in the transformation of the cast iron into wrought iron at the surface of the metallic bath, is always where it is exposed to oxydation, and as M. Berthier has said, it combines with the oxyd of iron, to form oxysulphids, which separate from the iron in the state of scoria and scales. I have never assayed the scoria from the refining without obtaining considerable quantities of sulphur. A careful analysis of a scoria from the refining that was very compact and contained no free iron, gave me 0·152 per cent of sulphur.

These facts established, I sought to prevent this action of sulphur in the high furnace, at least in part, by combining the observations of the learned Karsten (according to whom the best irons appear to contain at least 0·002 to 0·003 per cent of phosphorus) with the observations that I have made upon strong and hard irons made with coke mixed with very pure argillaceous and phosphatic ores. These last mentioned irons possessing none of the properties of the "fers de couleurs," are produced under the same circumstances as the "hot-short" iron which I obtained when the ores contained not the least sulphur, and the coke employed for their fusion was equally sulphurous.

The very soft iron "hot-short" resisted fracture when cold; the two extremities of the bar were brought to within 0$^{m}$·005 ($\frac{2}{10}$ of an inch) of each other without the least flaw or crack being distinguished in the bend, when the very hard iron has broken when the two extremities were within 5$\frac{1}{2}$ inches of each other, (the two pieces of iron used in these trials were of the same length). On the contrary, when the very soft iron, heated at a "cherry-red" was bent to two points, say A and B, it broke without presenting the least tenacity; while the very hard iron perfectly resisted the trial when heated at the same temperature.

The very hard iron, although less good when cold than the very soft iron, generally considered was preferable to the "hot-short" iron, the working of it heated being easier. These irons, as has already been said, were produced under the same circumstances, excepting the mixture of phosphatic ores for the very hard iron.

Persuaded then that phosphorus here plays an important part, I made some trials on a large scale in the high furnace by intro-

ducing phosphorus into the cast iron. I took for this purpose the ore of Villebois (Ain), an oolitic mineral very phosphatic, which, according to the analyses of M. Berthier (Essai par la voie sèche, t. II, p. 231), contains, Sesquioxyd of iron 34·8, water 12·6, phosphoric acid 0·2, clay 34·4, carbonate of lime 18·0. Owing to the large proportion of phosphorus, I added this ore in very small quantities so as not to obtain an iron "cold-short." Experiment determined that the proportion should be $\frac{1}{5}$ of the charge of ore.

I had then a bed of fusion equal to 240 kilogrammes (624 ℔s.) of cast metal containing $0^{k}{\cdot}106$ ($\frac{3}{1\,0}$ of a ℔.) of phosphorus, which gives an iron containing 0·00045 per cent of this element. I obtained by this means irons far superior to those previously obtained, and without any loss of its tenacity in the cold; they did not contain the least trace of the "hot-short" qualities. I will cite an example: A piece of iron $0^{m}{\cdot}055$ by $0^{m}{\cdot}015$ ($2\times\frac{1}{2}$ in.), manufactured without admixture of phosphatic ore, when heated, broke at every bend; and a piece of the same size manufactured from the cast metal, containing 0·00045 per cent of phosphorus, resisted fracture perfectly.

The explanation of this remarkable fact already recognized in practical metallurgy is thence apparent; the iron and the castings are much better as the qualities and varieties of ores mixed in the bed of fusion are more numerous, and the amelioration of quality is owing to the influence of foreign bodies, such as manganese and phosphorus, from the different ores.*

We cannot disregard, in this case, the influence of phosphorus, which was the only agent introduced into the new portion. The constitution of the slag was the same, and the cast metal had been produced under the same circumstances; the puddling and the reheating were made in the same manner and with the same fuel.

But how is it that the phosphorus can counteract the influence of the sulphur? This question I shall endeavor to answer by deduction from the facts and experiments made by me during the last two years, persuaded that it is of interest for science, since it throws light on the triple combinations of carbon, iron and phosphorus, besides being of great use in practice.

To arrive at a knowledge of this action of phosphorus upon sulphur in the cast metal, I made two experiments as follows. I remelted in a naked crucible in a forge: 1st, $3\frac{1}{2}$ gram. of an excellent gray white iron, containing much graphite with 0·14 pyrites (bisulphuret of iron). 2d, $3\frac{1}{2}$ gram. of the same iron

* *Note by W. J. T.*—According to Schafhäutl (J. fur Chem. xl, 304,) cast iron, bar iron and steel, almost always contain more or less arsenic and phosphorus. Thus the celebrated Dannemora iron and the English Low-Moor iron owe their good qualities to the presence of arsenic; and a particular kind of Russian iron (marked CC ND) from Demidoff's works at Nischnitagilsk is indebted for its peculiar properties to the phosphorus which it contains. (Gmelin, (Cavendish edit.), vol. v, p. 214.)

with 0·14 pyrites, 0·14 calcined bones, and 0·09 of a refractory white clay.

In these two trials I introduced into the cast iron a fixed quantity of sulphur: but in the last I added also a certain quantity of phosphorus; for the predisposing affinity of the silica for the bases at a high temperature would necessarily lead to the decomposition of the phosphate of lime of the calcined bones, and the phosphoric acid reduced by the carbon of the cast iron would combine with the iron to form a phosphuret of iron. The experiment succeeded perfectly. The fusion was complete and the temperature was pushed even to the softening of the crucible. The two buttons when broken were entirely white, as I have mentioned in a previous memoir, "*Sur l'influence de soufre sur la nature des fontes.*"

The button which contained only the sulphur, bent quite well under the hammer although the cast iron was of a very bad quality; it was only a mass of filamentary crystallizations of protosulphid of iron. This cast iron had a dull aspect, and it was very difficult to pulverize in a mortar; it flattened so as to afford small plates. Certain portions especially were very ductile. These portions doubtless contained some of the iron free: for it is known according to the researches of M. Fournet, "*Sur les sulfures metalliques*," contrary to the assertions of Karsten (Manuel de Metallurgie, p. 122), that the proto-sulphid of iron can be partially decomposed in presence of carbon at a high temperature. This learned geologist in heating to 150° (pyrometer) in a brasqued crucible some pyrites, obtained a button of protosulphid of iron which was scarcely at all magnetic. This same button, heated strongly a second time under the same circumstances, became after this second fusion strongly magnetic, from which fact it is concluded that a loss of sulphur had resulted, and a production of free iron in the proto-sulphid.

The button which contained some sulphur and phosphorus was, unlike the first, very brittle; it is easily pulverized and does not yield in the least under the hammer.

From this frequently exemplified fact in practice, the conclusion has been deduced: that phosphorus injures to a great degree the tenacity of cast iron. In the second button there could be distinguished by means of a lens parts of sulphurous crystallizations and some crystalline particles showing very brilliant facets.

The buttons from the two assays were pulverized and analyzed.

* * * The following are the result of two analyses.

The experiment made with pyrites alone gave with 1·77 gram.

| | |
|---|---|
| Sulphur not attacked by acids, - - - | 0·0150 gram. |
| Sulphate of baryta 0·33, sulphur, - - - | ·0455 " |
| | 0·0605=1·714 p. c. |

The fusion made with pyrites and burnt bones gave with 1·77 gram.

| | | |
|---|---|---|
| Sulphur not attacked by acids, - - - - | 0·0200 gram. | |
| Sulphate of baryta 0·23, sulphur, - - - | 0·0320 " | |
| | ·0520 | =1·486 p. c. |
| Loss of sulphur, - - - - - - | 0·228 " | |

Another gray iron fused with pyrites alone and again with pyrites and burnt bones gave by analysis of two grammes the following results:

| | | |
|---|---|---|
| Fusion with pyrites alone. Sulphur, - - | 0·0248 gram. | |
| " pyrites and burnt bones. " - | 0·0221 " | |
| | 0·0027 | =0·135 p. c. |

On comparing the results of the analyses, there is found in the one case a loss of sulphur equal to 0·228 p. c. of the weight of the iron, and in the other 0·135 p. c. in remelting with pyrites in the presence of phosphorus, since the two fusions of each iron were made in equal quantity of pyrites, and the loss of sulphur was greatest where the calcined bones were added.* I think therefore that this loss of sulphur was owing to the combination of a portion of this last, with the phosphorus introduced after fusion, these two bodies, in consequence of their great affinity, combining in all proportions to form some very volatile compounds.

To establish undeniably whether this probable combination had taken place, I made some reverse synthetic experiments; that is to say, I remelted:

1st. 5 grammes of a gray iron with 0·20 of pyrites, 0·20 of calcined bones and 0·10 of clay.

2d. 5 grammes of the same iron with 0·10 clay and 0·20 calcined bones, to see what became of the phosphorus after the second fusion in the presence of pyrites.

The two experiments gave me two buttons perfectly melted but entirely different in their external characters. The first, without being very ductile, flattened slightly under the hammer before breaking; its fracture was not smooth and shining as that of the button resulting from the fusion with the burnt bones without pyrites.

This last, on the contrary, was very friable, did not flatten under the hammer, broke at the first blow; it presented a perfectly smooth surface, was silver-gray, quite brilliant, without any fissure. Apart from its want of ductility it had many of the exterior characters of nickel.

* The sulphur in the first cast iron was not determined before fusion. It was of but little importance to know this quantity which was in proportion to the others in the two experiments of each iron. It was sufficient to know that it lost more by the addition of phosphorus.

So great a difference in the exterior characters of the two buttons was sufficient to make me believe in a loss of phosphorus through the presence of sulphur.

As a final test, I remelted again:

5 grammes of a gray cast iron with 0·20 of pyrites, 0·20 of calcined bones, and 0·20 of clay.

5 grammes of the same iron with 0·20 of calcined bones and 0·20 of clay.

Two grammes of each button from the fusion were analyzed.

* * * *

| | |
|---|---|
| Result of experiments with calcined bones gave phosphoric acid, | 0·024 |
| " " " " calcined bones and pyrites, phosphoric acid, | 0·027 |

It is seen from the two results of the analyses, that the phosphorus did not disappear in the fusion of the iron in the presence of phosphate of lime and pyrites, whilst the analyses in the inverse experiments showed a loss of sulphur which evidently could not have proceeded from a volatile combination of sulphur and of phosphorus as was first supposed.

M. Gruner, Engineer in chief of the mines, my excellent professor to whom I am indebted for numerous useful councils in this memoir, advised me to take again the first two buttons and examine the carbon, to assure myself if it did not play an important part in the disappearance of the sulphur.

He had in fact remarked, in an assay by the dry way of ores highly phosphatic, that some isolated granules of the fused metal which had no magnetic properties, rose to the surface owing to their feeble density, and which were, doubtless, phosphuret of iron without carbon; for had they been other than this, they would have been simply a phosphatic cast iron which would have possessed the magnetic properties of the fused button.

Indeed, it appears from the experiments which I have made, that phosphorus, tending to combine with the iron of the casting to form a phosphuret, replaces a certain portion of the carbon, which in its turn meets with sulphur from the pyrites and forms a sulphid of carbon independent of that which forms from the presence of pyrites alone without the concurrence of phosphorus.

In this manner we may explain the loss of sulphur, which has been proved to occur without a loss of phosphorus.

These analyses of carbon presenting great difficulties, particularly in the workshop of a metallurgist, I adopted the method of M. Regnault for the combustion of the cast iron, as it seemed the only convenient method of separating these small quantities of carbon.

In open crucibles by a forge fire were remelted:

1st. 10 grammes of very fine iron wire (No. 8 of commerce) cut into three small pieces, with 0·20 grammes of pyrites.

2d. 10 grammes of the same wire with 0·20 gr. pyrites, and 0·20 gram. of calcined bones.

The amount of sulphur in the two fused buttons were estimated in order to ascertain whether there had been a loss of sulphur as in the fusion of the cast iron, made under the same circumstances.

For if in these two trials the analyses gave the same amount of sulphur, it would be demonstrated that carbon was the sole agent which caused a loss of sulphur in the case of the fusion of the cast iron, and that the phosphorus by replacement of the carbon had assisted in this loss of sulphur. In melting the iron wire in the presence of pyrites and in an open crucible, it might be supposed that a loss of sulphur would occur by oxydation from the air, but such was not to be feared in this case, as a great quantity of iron covered the pyrites completely, preventing all contact with the air.

The two assays succeeded perfectly: the two buttons were well fused. That made with the phosphate of lime was very hard, breaking readily, from which it is seen that phosphorus tends to make iron very "cold-short." 1·90 grammes of each button of fusion were treated with boiling nitric and a little hydrochloric acid so as to dissolve everything completely, except some little granules of sulphur, which were readily collected.

The following are the results of the two assays;

1. Trial with pyrites and calcined bones;

| | | |
|---|---|---|
| Sulphur not attacked by acids, - - - | 0·0150 | |
| Sulphate of baryta, 0·03 : Sulphur, - - - | 0·0041 | |
| | 0·0191 | |

2. Trial made with pyrites alone;

| | | |
|---|---|---|
| Sulphur not attacked by acids, - - - | 0·0001 | |
| Sulphate of baryta, 0·065 : Sulphur, - - | 0·0089 | |
| | ·0190 | 0·0191 |
| | | 0·0190 |
| | | ·0001 |

From this it is seen that there is no material difference in the quantity of sulphur, since on calculating the sulphur in the sulphate of baryta to five decimals, there is only a difference of a tenth of a milligram. It may therefore be concluded that phosphorus removes no portion of the sulphur when iron is remelted in presence of pyrites and phosphorus.

On the contrary, when cast iron is melted with pyrites and phosphate of lime, there is always found a loss of sulphur.

The only difference in the results is in the carbon; and it follows, as before stated, that the loss of sulphur is to be attributed to its combination with carbon; a combination facilitated by the presence of phosphorus, which tending constantly to form a phosphuret of iron replaces a certain quantity of carbon.

We thence naturally infer that irons are less "hot-short" which are obtained with a mixture of phosphatic ores, because of the *influence of phosphorus in neutralizing partially the action of sulphur in the irons.*

These explanations give us also an explanation of a known fact in practical metallurgy, the explanation at present given being insufficient although partly true. There is no practical metallurgist who in treating very phosphatic ores has not obtained, contrary to his expectation, with a proper heat and slags, indicating a complete reduction,—some cast iron completely white.

It has always been supposed that phosphorus gave too great fusibility to the mass and accordingly prevented the formation of a gray iron. But to this explanation, which has some truth, there must be added the loss of carbon caused by the tendency of phosphorus to form a phosphuret of iron. For if the fusibility were the only cause, the slags should be slightly charged with iron, which is not the case. In all the synthetical trials and analytical results obtained, we find that phosphorus serves to remove a portion of the sulphur probably by favoring the separation of the carbon of the cast iron which then combines with the sulphur to form a sulphid of carbon.

Moreover, phosphatic irons, according to Karsten (Manuel de Metallurgie), preserve better their heat, pass more quickly to a white heat, a heat which spreads uniformly through the whole, whilst sulphurous irons, and as a consequence those "hot-short," cool rapidly and very unequally. The bar of forged iron in this condition presents no homogeneity, and breaks very easily. Hence in certain cases the influence of phosphorus, which is generally considered very injurious, may perhaps be advantageous. The metallurgist should use it with moderation, avoiding too great a quantity in the bed of fusion, as it is known that after cooling completely, phosphatic irons are brittle.

It is therefore necessary before using it to ascertain the required amount by a series of experiments on a large scale. These experiments should be made with much care, for, according to Karsten, it is known that the extreme limit of phosphorus in a good iron is 0·30 per cent; if this quantity is exceeded the irons lose their tenacity when cold and will not resist a shock or blow.

Very phosphatic and "cold-short" irons have ordinarily a grained fracture, with brilliant facets, without any fibres like many strong irons. The practical metallurgist ordinarily selects them for uses where the very soft slightly "hot-short" irons

would be disadvantageous, as in the manufacture of nails There is often also a demand for certain purposes for brittle iron.

It has indeed been remarked, but without explaining the fact, that certain coarse-grained "cold-short" irons forge very easily. We must not conclude from this (which has often been done), that all "cold-short" coarse-grained irons are always good when hot. In fact, a bad iron may be charged with silicium for instance, which will make it "hot-short" as well as "cold-short," and which will not work nearly as well as a fibrous iron well prepared and free from silicium. It is then necessary to ascertain first that the irons are cold-short from the presence of a small quantity of phosphorus, and not from the presence of another ingredient, or some cause inherent in the metallurgical treatment.

In all the experiments on a grand scale, made to favor the passage of the phosphorus into cast iron without compromising its quality by introducing silicium, I have always observed that the result from a charge containing equal quantities of clay and carbonate of lime was the best. In this case the slags have the following composition :

| | | Oxygen. | |
|---|---|---|---|
| Silica, - - - - - | 48·07 pr. ct. | 24·97 | 24·97 |
| Alumina, - - - - | 15·94 | 7·44 | 17·55 |
| Lime, - - - - - | 35·99 | 10·11 | |

These slags are well suited to a good result; for without being too silicious they are not injurious to the quality of the iron, in facilitating the reduction of the silica; neither do they contain too great a quantity of base to prevent the decomposition of the phosphates in the bed of fusion and the passage of the phosphorus into the cast iron.

In conclusion I will allude here to the memoir of M. Stengel, (Ann. des Mines, t. x, 3d série), who pretends to have assayed very sulphurous irons which were not in the least degree "hot-short." He contends that it is to copper that this property of iron must be attributed. Every one knows in fact that a feeble quantity of copper prevents iron from welding and renders it "hot-short" in a high degree. But I will say in opposition to M. Stengel, that this quality cannot ordinarily be attributed to copper, copper being very rarely present, but as a general thing, to the presence of sulphur. Besides, in all the trials on a large scale which I have made with care, if copper had been the cause of the "hot-short" iron which was obtained, there would have been "fers de couleur" at the time of treatment with charcoal as well as when the mineral coal was used, which was by no means the case.

When the irons obtained in la Bourgogne and la Franche-Comté by the use of charcoal and those derived from the same ores treated with mineral coal in the furnace of la Loire or the

Rhône, are compared, vast difference is found, the latter being very "hot-short," owing to the pyrites in the coal.

*Recapitulation.*—From the researches, experiments and analyses in this memoir, it will be seen:

1st. That traces of sulphur are sufficient to give a bad quality to iron and render it "hot-short."

2d. That the passage of sulphur into the iron takes place generally in the fusion of the ore in contact with mineral coal in a high furnace, and consequently it is in this operation that it must be counteracted.

3d. That phosphorus in the "bed of fusion" removes a portion of the sulphur in the cast irons by replacing a portion of carbon, and facilitating accordingly the formation of sulphid of carbon.

4th. That the quantity of phosphorus is not diminished when cast iron and irons are melted in presence of pyrites.

5th. That phosphorus in irons facilitates their being worked hot, rendering them harder and more difficult to cut.

6th. That it is necessary to study well the elements in the bed of fusion, so as not to introduce into the irons too great a quantity of phosphorus so as to render them too brittle when cold by its excess.

---

ART. XXV.—*On a Subsidence of the Land on the Sea-coast of New Jersey and Long Island;* by Professor GEO. H. COOK, of Rutgers College, New Jersey.

(Read before the American Association at Montreal, Aug. 13th, 1857.)

IN the course of some geological examinations along the coast of Southern New Jersey, my attention was frequently called to various facts indicating a change in the relative level of the land and water, at some recent period. An attentive examination of these facts has led me to the conclusion, that a gradual subsidence of the land is now in progress throughout the whole length of New Jersey and of Long Island; and from information derived from others I am induced to think that this subsidence may extend along a considerable portion of the Atlantic coast of the United States.

The occurrence of timber in the marshes and water below tide-level is common along our whole Atlantic shore. Almost every person at all familiar with shore life has observed the remains of logs, stumps and roots in such places. Generally, however, they have been looked upon as the remains of trees, torn from their original places of growth by torrents or by the wearing away of the shores, and deposited where they are found by the ordinary action of the water. To any one who examines

them carefully it soon becomes evident that they grew upon the spots where they now are. The stumps remain upright; their roots are still fast in the firm loamy ground which underlies the marsh—and their bark and small roots remain attached to them. The localities, too, where they are most abundant, are such as are least liable to be affected by the violent action of the water or of storms. Thus they are by far the most abundant on the low and gently sloping shores of Long Island, New Jersey, and all the states farther south, which are protected from the violent action of the surf by a line of sand beaches, at the same time that the numerous inlets allow free access to the tides. In these protected situations, hundreds and even thousands of acres can be found, in which the bottoms of the marshes and bays are as thickly set with the stumps of trees, as is the ground of any living forest.

The first and the chief part of my own observations were made upon the southern part of New Jersey, following the shore of Delaware Bay from its head down to Cape May, and the Atlantic shore from Cape May north to Great Egg Harbor. The examinations have since been continued along the shore to New York City, and thence eastward at several points along the south shore of Long Island.

In the marshes above Salem, great numbers of the stumps and trunks of trees are met with in digging ditches at all depths quite down to the solid ground.

It will be remembered in the frequent allusions made to the marsh, that its surface is nearly on a level with high tide mark, and, of course, that whatever is buried in it is below that mark.

At Elsinboro Point, a little farther down on the Delaware Bay shore, the cutting away of the marsh by the water has left great numbers of stumps exposed, and they can be seen at every low tide, still firmly rooted in the hard ground. In the bank of Alloways Creek, a few miles below, the remains of trees can be seen under the same circumstances. They are common in all the marshes of Cumberland Co. Great numbers of them can be seen in the marshes on Maurice River at Dorchester and below.

In Cape May county they are observed everywhere in the marshes and creeks; good localities are to be found at Dennisville on the Delaware Bay, on the inside of Seven-mile Beach, on the sea-side, and below Tuckahoe on Great Egg Harbor.

They are common in the marsh which extends along the whole shore back of the beaches quite to Squan. Great numbers of them can also be seen at low water on the strand at Point Comfort, opposite Sandy Hook.

In the marsh on the Raritan above South Amboy, hundreds of them were dug out in cutting a canal across a bend in South River.

The marshes about the mouths of the Passaic and Hackensack rivers are filled with the remains of cedar timber.

The marshes on Staten Island also contain buried timber; and on Long Island at Hempstead, at Babylon, at Islip, and still farther east, the same fact is of constant occurrence.

I may remark that the remains of trees are not equally abundant in all localities, owing partly perhaps to differences of exposure, but more to the difference in durability of the various species of wood. In many places where oak, gum and other deciduous trees were known to stand formerly, there are no traces of them now; they have entirely rotted away. On the contrary, the pine and the red and white cedar are almost indestructible. I have seen pine stumps several feet under the marsh, where they have been for an unknown period, which retain the characteristic smell and appearance of the wood almost as perfectly as the fresh cut specimens. At several places in southern New Jersey an enormous amount of white cedar timber is found buried in the salt marshes, sound and fit for use, and a considerable business is carried on in mining this timber and splitting it into shingles for market. In some places it is found so near the surface that fragments of the roots and branches are seen projecting above the marsh, while in other cases, the whole is covered with smooth meadow sods, and there is no indication of what is beneath till it is sounded by thrusting a rod down into the mud.

It is in deposits where these durable species of wood are found that we get the most accurate idea of the depth to which these remains extend. At Dennisville, there is a large tract of marsh underlaid by cedar swamp earth and timber. By probing the marsh with an iron rod the workmen find where the solid timber lies, and then, removing the surface sods and roots, they manage to work in the mud and water with long one-handled saws, and cut off the logs, which, as soon as they are loosened, rise and float, and of course are easily managed. The timber is not water-logged at all, but retains its buoyancy, and the removal of that nearest the surface releases that which is below and it rises, so that a new supply is constantly coming up to the workman. In this way a single piece of swamp which is below tide level has been worked for fifty years past and still gives profitable returns. The timber is found lying in every direction, some appearing to have been blown down by the wind, and some to have died and fallen after it was partially decayed. The fallen timber has been covered by the accumulation of muck from the decayed leaves and twigs, and other timber has grown on this, to fall and in its turn give place to still another growth. How long this accumulation has been going on it is impossible to tell. Dr. Beesley of Dennisville counted 1080 rings of annual growth

in a stump, and lying directly under this, so that it must have fallen before this grew, was a log with 500 rings. I have seen them lying in this way, log under log, indicating that thousands of years must have passed while they were accumulating. And this is only the superficial portion of it. In some of the creeks in the marsh, there are hundreds of stumps which only fall bare at extreme low water, and both in Dennis Creek and in Maurice River there are fast stumps on which there is seven or eight feet water at low tide. With an instrument for sounding marshes, I have been able to find these logs as low as eighteen feet below the surface of the marsh; and the material brought up from that depth was cedar swamp earth. In digging a well in the marsh at Dennisville, a foot or two of marsh mud was passed through, and then swamp earth or muck quite down to the gravelly bottom, which was reached at eleven feet. Most of the timber found was cedar, but at the bottom and fast in the hard ground was gum and magnolia.

Facts of the kind mentioned above are by no means confined to the shores of New Jersey and Long Island. Prof. Hitchcock, in his Geology of Massachusetts, p. 307, says a "submarine forest exists at Holmes's Hole, on Martha's Vineyard. It is on the west side of the harbor, and was described by the pilot as having the appearance of a marsh at low water. Stumps have been found there in considerable quantity, of the cedar at least.

"Near the southwest extremity of the Vineyard, on the north shore, I was informed that another forest of similar description may be seen. On the north side of Cape Cod, also, opposite Yarmouth, cedar stumps may be found (as I was informed by the captain of the Falmouth packet) extending more than three miles into Barnstable Bay. And Mr. Henry Wilder, of Lancaster, who first directed my attention to this subject, says that the same thing occurs in the Bay of Provincetown, on the side opposite the village."

Sir Chas. Lyell, in his Second Visit to the United States, vol. i, p. 33, in speaking of the country about Portsmouth, N. H., says, "it is a curious fact that we discover along this eastern coast unequivocal signs of partial subsidence of land at a recent period. The evidence consists of swamps, now submerged at low water, containing the roots and upright stools of the white cedar, showing that an ancient forest must once have extended farther seaward. One of these swamps we passed yesterday at Hampton, on our way from Boston to Portsmouth."

In Dr. Jackson's Report on the Geology of New Hampshire, p. 280, an article by J. L. Hayes of Portsmouth, mentions that at Rye Beach, "among the curious phenomena which may be witnessed, are the remains of a submerged forest. The stumps and roots of trees of a large size, are frequently seen during very low

tides, on the lower margin of the beach. They appear to have been broken off near the roots, which remain in their original positions. The trees were mostly white cedar. . . . . Stumps of trees are found in most of the salt marshes around Portsmouth."

In the second volume of Lyell's First Visit to the United States, p. 143, where he speaks of the flats on the Bay of Fundy, he says, "I was informed that there was a submerged forest buried in the red mud, and exposed to view in the Cumberland Basin at low tide, not far from Fort Cumberland."

Prof. Dawson, in a paper, On a Modern Submerged Forest at Fort Lawrence, Nova Scotia, published in the Quart. Journ. Geol. Soc., vol. xi, p. 119, mentions that, "outside of the edge of the marsh, and about twenty-five feet below the level of the highest tides, which here rise in all about forty feet, .... appear erect stumps and many prostrate trunks of trees. The stumps are scattered as in an open forest, and occupy a belt of 135 paces in breadth, and extending on either side for a much greater distance. I saw more than thirty stumps in the limited portion of the belt which I examined. . . . On digging around some of the stumps, they were found to be rooted in ground having all the characters of ordinary upland forest soil. . . . . The smallest roots of all the stumps were quite entire and covered with their bark, and the appearances were perfectly conclusive as to their being in the place of their growth. . . . . All the stumps and trunks observed were pine and beech, and it is worthy of notice that these are trees indicative rather of dry upland than of swampy ground."

Edmund Blunt, Esq., of New York City, informs me that he had observed the various phenomena connected with the submerged timber, on the south shore of Long Island, and on the shores of Delaware and Chesapeake Bays, and that he made them the subject of a verbal communication to the New York Lyceum twenty years ago.

Dr. Emmons, State Geologist of North Carolina, has observed submerged forests under similar circumstances in Albemarle Sound.

Lyell, in the account of his First Visit to the United States, vol. i, p. 131, says, "at Beauly, in Georgia, I found upright stumps of trees of pine, cedar, and ilex, covered with live oysters and barnacles, and exposed at low tide; the deposit in which they were buried having been recently washed away from around them by the waves." And at p. 139, "near the mouth of Cooper River in S. Carolina, in the marshes, there are deep deposits of clay and sand enclosing the stools and trunks of the cypress, hickory, and cedar, often imbedded in an erect position, which must have grown in fresh water, but are now sunk six and even sixteen feet below the level of high water."

Wm. Bartram, in his Travels in North and South Carolina in the last century, says, "It seems evident even to demonstration that those salt marshes adjoining the coast of the main, and the reedy and grassy islands and marshes in the rivers, which are now overflowed at every tide, were formerly high swamps of firm land, affording forests of cypress, tupelo, Magnolia grandiflora, oak, ash, and sweet bay, and other timber trees, the same as are now growing on the river swamps, whose surface is two feet or more above the spring tides that flow at this day. And it is plainly to be seen by every planter along the coast of Carolina, Georgia and Florida to the Mississippi, when they bank in these grassy tide marshes for cultivation, that they cannot sink their drains above three or four feet below the surface, before they come to a stratum of cypress stumps and other trees, as close together as they now grow in the swamps."

There is another class of facts somewhat similar to those above-mentioned, and of common occurrence along our shores, from which these should be distinguished. The facts to which I refer are such as the following. At Cape Island, Cape May county, there are found stumps of oak trees at tide level which have been covered by twelve or fourteen feet of upland soil—cultivated farm land—and have but recently been exposed by the wearing away of the shores. At Union, on Raritan Bay, in solid earth and about two feet below low water, common hard wood stumps were found, in digging a large basin. Upright stumps of trees have also been found in digging wells on the upland, at numerous places near tide water, on Delaware Bay and the Atlantic shores. In similar localities, shells of the common clam, oyster, and other recent species have been found in wells, and I have observed them at various places several feet above high tide.

In the bank of Maurice River, seven or eight feet above high water and still covered by several feet of sandy earth, is an oyster bed. It is exposed for some rods. The shells are in common blue mud, closely wedged in together, and standing with the opening of the valves upwards, just as in the living beds. At Tuckahoe, casts and impressions of the common clam are found in the gravel at eight or ten feet above high water. And at Port Elizabeth and near Leesburgh, shells of the clam and oyster, and indeed of nearly all the species of shells now common in the bay are found, covered by from two to six feet of sandy loam, and are extensively dug for manure. I was lately informed of the existence of an oyster bed under similar circumstances on the beach a little north of Long Branch. Deposits of recent shells are found in much the same way, on all our Atlantic coast, and also on the Gulf of Mexico. So many have been given by different observers, that for the present purpose it is

not necessary to specify them. Attention is called to them now as indications of a period of subsidence, and then one of elevation preceding the present.

The fossils, it will be perceived, are in circumstances which require that the ground should have occupied a much lower relative level than the present, and the covering which is over them is upland soil,—portions of that in New Jersey are in cultivation,—and are among the most valuable and productive soils in the state. While on the contrary the remains of trees, &c. which are specially referred to in this paper are all as low as the present level of high tide and are covered only by water or by marsh mud and roots. They are also of a much more recent date, some of them having been growing trees within the memory of persons now living, and the subsidence which has produced them is one that is still in progress as I wish now to show.

In referring to the facts it will be convenient to follow the same geographical order which has been observed before.

In Elsinboro, on Delaware Bay, a portion of what is now tide meadow was a heavily timbered maple swamp since the country was first settled, and after this had died out and been replaced by marsh there still remained in the midst of it a knoll or island, as it is locally termed, of hard ground covered with timber. Now this timber too is all dead, and the island is lost in the marsh. The inhabitants say the tides run higher on the upland than they formerly did. It manifestly is not caused by any washing away of the soil. On Alloway's Creek there was a considerable island in the unbanked marsh which was cultivated for corn, wheat, and other farm crops within the present century; but now it is overflowed by high tides, and is covered with marsh mud and grass. A surveyor in extensive practice,* in Cumberland Co. west of the Cohansey, informs me that there are a number of such instances which have come under his own observation. He referred me to one island of considerable size, which in the early survey of the country is described and mapped as being covered with timber. No timber is now to be seen there, and the island is no longer upland. Its place is only ascertained by sounding the marsh, when it is recognized by the shallower deposit of mud and roots on it. Other instances of the same kind were mentioned to me on the east of the Cohansey, of precisely the same character.

The owner of an extensive tract of land between Maurice River and West Creek† informed me that within the last 50 years he had lost 1000 acres of timber,—by the tides running higher on the upland than they formerly did. On Stipsons Island I was shown portions of upland on which good crops of

* Belford M. Bonham, Esq. † Joshua Brick, Esq.

wheat had been raised within 30 years; now it is liable to be overrun by the tide, and cannot be cultivated. In the last 50 years this farm which is of perhaps 200 acres, has lost 50 acres, part wood and part cultivated land, from this cause.

At Dennisville, and indeed along the whole of the Bay shore of Cape May, the same fact is to be observed. Wherever the shores are low and the slopes gentle, the lower edges of the woodlands and also scattering trees near the marsh are liable to be killed by the tide, and every year shows advances of the water upon the land by the dead trees which it leaves,—and which are never replaced by a new growth of young timber, but by salt marsh.

On the sea-side of Cape May the shore is bolder and of course the encroachments are less perceptible, but even here numerous instances were related to me, by persons who had observed them, of the killing of timber by the tide,—and on the west side of the beaches I saw great numbers of dead red cedar trees still standing in the marsh; the earth in which they grew covered by a few inches of mud,—and liable to be overflowed by high tides. The dying out of oak and other hard-wood timber was also shown to me at Barnegat. On Squan Beach there is a considerable tract exposed at about half tide, from which the timber was cut off sixty or seventy years ago, and the stumps are standing yet. At South Amboy on Raritan Bay I saw three or four dead white oak trees, all that were left of a grove of 150 trees which flourished there thirty or forty years ago. They were on a slope which was formerly covered with grass, but the sandy gravel has been driven in by the storms,—the grass and trees are killed. Capt. Peterson an old inhabitant of Washington on the Raritan, says that a portion of what is now salt marsh was formerly a swamp; and that a sandy point projecting into and partly covered by marsh was within his recollection covered with pine trees.

At Hempstead on Long Island, an old resident, Mr. Valentine Smith, informed me that he knew of an island, in his meadow, which was covered with trees since his recollection, but which is now salt marsh; and the highest part of the island is lower than the surface of the meadow.

The district of country where the principal part of my observations have been made is particularly favorable to the detection of changes of level in the tide waters, on account of its low shores, and its being so generally protected from the direct action of the waves or of currents. Most of the Jersey shore of Delaware Bay and of the Atlantic is fringed by a strip of salt marsh, in many places several miles wide. High tides flow over these it is true; but not to any considerable depth, so as to produce currents that could wear the upland, and they do not appear

to wear it at all. The land is very low and level. In the whole county of Cape May there is not a hill of any magnitude. To give an idea of the uniformity of its surface I may mention that a railroad line twenty-four miles long, was surveyed through the central and highest part of the county, in which the greatest elevation passed over was twenty-eight feet above high water, and the average was but eleven feet. The land near the shores in the adjoining counties is equally low. On such shores it will readily be perceived that a very slight depression of the surface must bring a broad strip of land under water and that marks of such depression will be found in much greater abundance than in localities where the shores are bolder.

The people along the shore in such places are very sensible of this change of level between the land and water, and are perfectly well satisfied that the remains of the timber found are in the places where they grew, and that they have not gone down by the ground washing away, or becoming more compact. When it was objected to them that the white cedar trees have no tap roots but grow directly upon the muck, and of course that they might have settled; it was readily admitted that one might think so, but for the fact that when the cedar grows so that its roots can reach hard ground as they can when the swamp is shallow, that then the timber is worthless on account of the fibres interlocking so that it cannot be split into shingles, and that in shallow swamps and in the bottoms of the deeper swamps, such timber is found, which is to them a plain evidence that it grew there. Further they find at the bottom of such swamps gum and magnolia trees which have grown upon the hard ground. Pine stumps are also found at considerable depths below the surface; these are tap-rooted, and their roots reach the solid ground so that they are not liable to settle. It is the general impression however, that the cedar swamps do not settle as long as they remain constantly wet.

Many of the residents who have observed this gradual encroachment of the water and marsh on the upland, have accounted to themselves for it by a variation in the rise of the tides;—saying that the mouth of Delaware Bay and of the Inlets on the sea-shore are more obstructed than formerly and thus cause the tides to rise higher. I do not know whether the obstructions are as they state, but if they were so as to affect the flow of the tide, high-water mark would be lowered and not raised. But this is probably not of much importance, as the tide at Cape May rises only about five feet, and the changes of level which have been mentioned are more than equal to the whole of this.

Mr. Edmund Blunt of New York who agrees with me in regard to the apparent subsidence, is disposed to account for it by supposing that it is in some way dependent on the clearing and

cultivation of the ground, and that it ceases about buildings and other structures. It will be perceived, however, that many of the cases I have cited are of wood land which has been overrun by water before it was cleared.

Prof. Tuomey in his Report on the Geology of South Carolina refers to numerous facts to show that the opinion of a subsidence of the coast of that state, originally advanced by Bartram in his Travels, and since sustained by Lyell in Proc. Geol. Soc., vol. ii, p. 406, is incorrect. He concludes that "there is not a single instance of submerged swamp that cannot be traced to the encroachment of the ocean, without supposing any change in the relative level of land and water on the coast.

"Those writers who have referred them to the latter cause erred in not having first studied the nature and level of the swamps in which the trees grew whose stumps are found submerged, and in not distinguishing tap-roots from true stumps."

I do not think the cases to which I have referred are open to this objection, as many of them were of upland forests and not swamps at all.

Prof. Hitchcock in a paper on the Geology of Portland and vicinity, (Bost. Jour. Nat Hist., vol. i, p. 338,) and J. L. Hayes, Esq., before quoted, do not think the instances they have cited are proofs of subsidence, but that they are only low lying swamps, originally shut in from the salt water, but which by the wearing away of the shores have been exposed to the action of the sea which has washed out the muck and lowered the stumps. Such an explanation would not apply to the cases of the islands which I have mentioned or to those along the sloping shore.

Mr. J. W. Dawson, in an article which I have before quoted, after mentioning a popular explanation connected with some observations at the mouth of the Bay, but which he thinks insufficient, says: "The only remaining mode of accounting for the phenomena, is the supposition that a subsidence to the amount of forty feet has occurred in the district. Such a subsidence is not likely to have been limited to Fort Lawrence Point, and accordingly I have been informed by intelligent persons long resident in the neighborhood that submerged stumps have been observed at a number of other places in circumstances which showed that they were *in situ*, and that trees and vegetable soil have been uncovered in digging ditches in the marsh. Nor are these appearances limited to Cumberland Basin. At the mouth of Folly River, on the southern arm of the Bay, a submerged forest on an extensive scale is said to occur, and in the marshes at Cornwallis and Granville vegetable soils are found under the marsh. These facts render it probable that the subsidence in question has extended over the whole shores of the Bay, and that the marshes have been deposited, and the present lines of coast-cliffs cut, since its occurrence.

"The marshes of the Bay of Fundy are known to have existed at or about their present level for 250 years. It is true that an opinion prevails in some of the marsh-districts that the tides now rise higher than formerly, and in proof it is alleged that the dykes are now maintained with greater difficulty, and that tracts of marsh once dyked have been abandoned. The settling of the mud and the narrowing of the tidal channels by new embankments may however have produced these effects. For the antiquity of these submerged forests we must therefore add to the two centuries and a half which have elapsed since the European occupation of the country, a sufficient time for the deposition of the alluvium of the marshes. On the other hand the state of preservation of the wood, after making every allowance for the preservative effects of the salt mud, shows that its growth and submergence must belong to the later part of the modern period."

From the pilots who go out of New York harbor I have not been able to learn that they have observed much variation in the depth of water in the channel, but they say that they probably should not notice it. The report of the Harbor Commissioners shows that local causes are in operation which affect the harbor of New York much more than this regular and slow one. Two intelligent pilots who go out of the Raritan River inform me that there is a greater depth of water in that river than there was thirty years ago.

After examining all I have been able to find written upon the subject, and after studying it in the field, I can think of no other theory which will apply to all the facts except that of a slow and continued subsidence of the land.

The rapid wear of the shores may fairly be adduced as confirming my conclusions in regard to subsidence. A few cases of this rapid wear may be given. Egg Island, a point well known to those who are familiar with Delaware Bay, is put down on the first map made by the proprietors of West Jersey in 1694 as containing three-hundred acres of land. It now contains only about three-fourths of an acre at low water, and high tides cover it entirely. I am assured by a surveyor* who has long been engaged in his business, and has traced out many old lines which formerly terminated on the shore, that the wear of the salt marsh along Maurice River Cove since the first settlement of the country, is not less than three-fourths of a mile. At the mouth of Dennis Creek the wear is very great—forty rods have been worn off in three years,—and boatmen there tell me that the distance from Dennisville to the Bay is less by a mile than it was when they first knew the creek. At Town Bank the upland comes out to the shore in a bold bank from fifteen to twenty feet high.

* James L. Smith, Esq.

The first settlement in Cape May county was made at this spot, but the site of the buildings, and a grave yard which was back of them have been entirely worn away. The light house at the Cape has been moved inland considerably, on account of the wearing away of the shore. At Cape Island about the year 1780, what is now the bathing ground and on the ocean shore, was a mile inland, and the space between the houses and the shore was cultivated ground. Poverty Beach, now a short sand bank, was then Four mile Beach and extended from Cold Spring Inlet to the point of Cape May.

The beaches farther up the shore which are exposed to the direct action of the sea wear away rapidly, and where they are narrow and not covered with timber they drift in towards the land. In some cases they have moved in their entire breadth and now rest on the salt marsh which formerly was behind or to the west of them. This wear is common along the whole of the Jersey shore. Capt. J. W. Herbert a very intelligent wreck master at Keyport has a number of marks on the beaches set to determine the location of sunken vessels, and from these he is able to measure the wear from year to year, and the average which he deduces from these is not less than twelve feet a year along the whole shore. He verifies these measurements further by the position of the vessels themselves; some of them were buried in sand in the bar which is outside of the shore and parallel with it, and others were inside of this. After a few years these vessels are found outside of the bar, in deep water and clear of sand; the shore has worn away and the bar has followed it in.

At Long Branch, which is hard upland, the wear is very serious. The spot where the first boarding house was located, thirty years since, together with the road which ran behind it, is now all worn away, and the shore line is to the west of it. The wear is irregular; last year it was from twelve to twenty feet. Along the shore of Sandy Hook and Raritan Bays the wear is equally rapid. At the Highlands enormous slides have been the result of this wear. At Union the washing away has averaged three or four feet a year for three years past. At the mouth of Cheesequakes the channel is now where there were cultivated fields sixty or seventy years ago. The elm tree, formerly a prominent land-mark on the south shore of Staten Island, is gone and it is said the water is of some depth where it stood. On Long Island the wear of the beaches is not so uniform, but is perceptible. On the east end of the Island the wear is very great and has attracted attention ever since the first settlement of the country, for details of which reference may be made to Mather's Geol. Rep. in Nat. Hist. of New York.

In regard to *the rate at which this subsidence is going on*, I may state a few facts. On Oldman's Creek is a tide meadow

which was banked in soon after the settlement of the country, perhaps 150 years ago. The sluices in this bank are now full three feet below low-water mark, so low that they are entirely useless, and it is a puzzle to the inhabitants to know what they were ever put there for. The meadows on the north side of Alloway's Creek were also banked about 150 years since. The sluices in these banks are full three feet below low tide, and useless. I am assured by those who are familiar with such sluices that they are not liable to settle in the mud when properly placed. On the south side of the same stream, where the hard upland comes to the waters edge, the stump of a tree is standing, which has been cut down since the settlement of the country, and now, though it is still firm in the gravelly and tenacious soil of the hard ground, every high tide runs over it. The very intelligent farmer* who pointed it out to me, said there were several others of the same kind farther down the stream. The wood was oak; standing as they did, he thought they would have been killed by the tide before it came within three feet of its present height. On the Cohansey at Bridgeton, Mr. David Reeve who was concerned in the iron works there, made observations upon the tides for twenty years from 1816. The log on which he marked the result of his observations is now lost; but he says confidently, "that the tides uniformly, when uninfluenced by winds, rose higher than when my observations commenced, but how much higher I am now unable to inform you."

At Bateman's mill on Cedar Creek in the same county, the miller assures me that the tides rise eight inches higher on his wheel than they did twenty-five years ago.

The Hon. Joshua Brick of Port Elisabeth, who is noted as an accurate observer, gives it as his judgment that the tides rise upon the upland a foot higher than they did fifty years ago.

A water mill at the head of tide on West Creek, as I am informed by Benjamin Goffe, Esq., was very carefully located so that the wheel should not be affected by the tide backing up against it. It was built fifty-two years ago, and then it was very rare indeed for it to be stopped by the tide. Now it is stopped a number of times every year, and it is the opinion of those most competent to judge, that the tide rises fifteen inches higher on the wheel than it did formerly, and they are sure it is not less than twelve inches.

A water mill standing on Sluice Creek has been built 100 years, and the owner† informs me that from old papers in his possession he thinks it has lost two feet of head,—indeed it is only kept running by a dam and sluice some distance below.

* Mr. Thomas Shourds. † Clinton Ludlam Esq.

A tide mill on the sea-side, about two miles below Beeseley's Point, was attended by the same miller* for twenty-five years, and he informs me that he knows he lost four inches in the head of water in that time, and may have lost more.

From these several results—three of a subsidence of *three feet* in one hundred and fifty years, one of *two* feet in one hundred years, two of *one* foot in fifty years, and one of *four inches* and one of *eight inches* in twenty-five years,—we may with some degree of probability, set the average subsidence in the district where the observations were made, at two feet in a century.

With the exception of the statements of two pilots upon the Raritan River I have nothing upon which to base any estimates for the present rate of subsidence in the vicinity of New York. One of the pilots founds his conclusion upon observations made upon the wharf at Washington, and he is confident there is eight inches more of water there than there was twenty-five years ago. The other draws his conclusions from the depth of water upon the reef of rocks in the river below New Brunswick, and the depth upon the middle ground near Amboy, and from the action of the centre board of the vessel which always touches at these points, he is satisfied that the water is deeper than it was thirty years since; but he thinks not six inches deeper. The opportunities for accurate observation are much less frequent here than in the southern part of New Jersey, but from the phenomena of the marshes and of the submerged forests on Long Island and in northern New Jersey, I should infer that there was no material difference in the rate from that already deduced.

This paper is presented for the purpose of calling attention to the remarkable and important phenomena of which it treats. I purpose to continue the investigation, and shall be glad to receive statements of facts bearing upon the subject; either for or against the conclusions to which I have arrived. Facts in relation to the *rate* of subsidence are particularly desirable. I have given all that have come to my knowledge, and they agree singularly well with each other; but it is not unlikely that other and more numerous observations may give a different result.

New Brunswick, N. J., August, 1857.

* Mr. Nicholas Godfrey.

# Art. XXVI.—*Biographical Memoir of William C. Redfield*;* by Professor Denison Olmsted, of Yale College.

[From a Discourse delivered before the American Association for the Advancement of Science, at Montreal, August 17th, 1857.]

Mr. William C. Redfield, the well known author of a theory of Storms, and of various other valuable contributions to science, died at his residence in New York, February 12, 1857. A life passed in the ordinary walks of business, or in the quiet of philosophical research, affords little of that romantic incident which lends a charm to biography; still we think the life of Mr. Redfield will be found interesting and instructive in a three-fold point of view,—as affording a marked example of the successful pursuit of knowledge under difficulties,—as happily illustrating the union, in the same individual, of the man of science with the man of business,—and as exhibiting a philosopher, whose researches have extended the boundaries of knowledge, and greatly augmented the sum of human happiness.

William C. Redfield was born at Middletown, Connecticut, on the 25th of March, 1789. He was of pure English descent both by the father's and mother's side. His father from a natural love of adventure, chose in early youth a sea-faring life, and afterwards followed the seas as a profession to the time of his death, which happened when this, his eldest son, was only thirteen years old. His early training, therefore, devolved chiefly on his mother, who was a woman of superior mental endowments, and of exalted Christian character.

The slender pecuniary resources of the family would not allow young Redfield any opportunities of school education beyond those of the common schools of Connecticut, which, at that time, taught little more than the simplest rudiments—reading, spelling, writing, and a little arithmetic; and all access to the richer treasures of knowledge seemed to be forever denied him, when, at the early age of fourteen, he was removed to Upper Middletown, now called Cromwell, and apprenticed to a mechanic, whose tasks engrossed every moment of his time except a part of his evenings. These brief opportunities, however, he most diligently spent in the acquisition of knowledge, eagerly devouring every scientific work within his reach. He was denied even a lamp for reading by night, much of the time during his apprenticeship, and could command no better light than that of a common wood fire in the chimney corner. Under all these disadvantages, it is evident that before he was twenty-one years of age he had acquired no ordinary amount and variety of useful knowledge.

* We give place to this sketch of the life and scientific labors of the late Mr. Redfield with the more pleasure, since the earliest and the largest portion of his subsequent philosophical papers have been published in this Journal.—Eds.

During the latter part of his apprenticeship he united with other young men of the village in forming a debating society under the name of the "Friendly Association," with which was connected a small but growing library. To this humble literary club, Mr. Redfield always ascribed no small agency in inspiring him with a love of knowledge, and a high appreciation of its advantages; and during his future years, he nursed and liberally aided by his contributions this benefactor of his youth.

Fortunately for young Redfield, a distinguished and learned physician, Dr. William Tully, fixed his residence in the same village, and generously opened to him his extensive and well-selected library; and what must have been equally inspiring to youthful genius, Dr. Tully furnished him with a model of an enthusiastic devotee to knowledge, and of a mind richly stored with intellectual wealth. The modest youth who first presented himself as a suppliant for the loan of a book from the Doctor's library, was soon recognized as a congenial spirit, and was admitted to an intimate friendship, which lasted to the day of his death. Dr. Tully has favored us with the particulars of his first acquaintance with our friend. On his application for a book to occupy such moments as he could redeem from his daily tasks, the Doctor, being then ignorant of his acquirements or his taste, opened different cases of his library, submitting the contents of each to his selection. Among a great variety of authors, that which determined his choice was Sir Humphry Davy's Elements of Chemistry. As this was one of the earliest systematic works that contained the doctrine of Chemical Equivalents, a subject then considered as peculiarly difficult, and one understood by few readers of the work, the Doctor had little expectation that his young inquirer after knowledge, would either understand or relish it. In a short time he returned the book, and surprised the Doctor by evincing a thorough acquaintance with its contents, and expressing a high satisfaction, in particular, with the doctrine of chemical equivalents, which, he said, he had then met with for the first time.

Some time before young Redfield reached the end of his apprenticeship, his widowed mother had married and removed to the state of Ohio. He was no sooner master of his time than he set out on foot to pay her a visit in her new home, distant more than seven hundred miles. It was a formidable undertaking, in that early period before the age of steamboats and railways, and when a large part of the way was covered with dense forests, with hardly an open path even for the pedestrian. Stage coaches, indeed, ran on the nearer portions of the route, but these were too expensive for the slender finances of our young adventurer. Accompanied, therefore, by two other young men, he shouldered his knapsack and commenced the arduous journey. Every evening he noted down the incidents and observations of the day.

This journal is now in my possession, and I have perused it with deep interest for the graphic sketches it contains of the countries he passed through, then mostly new settlements, and for the indications it affords of those powers of observation, which afterwards led to the development of the laws of storms. The style of composition is far superior to what might reasonably have been expected from one who had enjoyed so few literary advantages, evincing two qualities for which Mr. Redfield was always distinguished—good sense and good taste. The sketches of Western New York, and of Northern Ohio, taken while the sites of Rochester and Cleveland were dark and gloomy forests, and Buffalo was a mere hamlet, possess no ordinary degree of historical interest. Instead of a "Lake Shore" road, traversed by the iron horse, as at present, our young pedestrians could find no better paths in which to travel over the southern side of Lake Erie, than to course along the beach. Yet in twenty-seven days they made good their journey, having rested four days on the way, making an average of about thirty-two miles per day. After passing the winter with his friends in Ohio, he resumed his way homeward on foot and alone, returning by a more southern route, through parts of the states of Virginia, Maryland, and Pennsylvania. We shall soon see to what valuable account he afterwards turned the observations made on these early pedestrian tours, in tracing the course as well as originating the project, of a great railway connecting the Hudson and the Mississippi rivers.

Returning to his former home in 1811, Mr. Redfield commenced the regular business of life. No circumstances could seem more unpropitious to his eminence as a philosopher, than those in which he was placed for nearly twenty years after his first settlement in business. A small mechanic in a country village, eking out a scanty income by uniting with the products of his trade the sale of a small assortment of merchandize, Mr. Redfield met with obstacles which in ordinary minds would have quenched the desire of intellectual progress. Yet every year added largely to his scientific acquisitions, and developed more fully his intellectual and moral energies. Meanwhile his active mind left its impress on the quiet community where he lived, in devising and carrying out various plans for advancing their social comfort and respectability, in the improvement and embellishment of their streets, school houses and churches, and in promoting the interests of the literary club, from which he himself, in early youth, had derived such signal advantages. From deep domestic trials which afflicted him about the year 1820, he had recourse for solace both to the word and the works of God. It was soon after one of the severest of these trials, that his attention was first directed to the subject of Atlantic Gales.

On the 3d of September, 1821, there occurred, in the eastern part of Connecticut, one of the most violent storms ever known there, and long remembered as the "great September Gale." Shortly after this, Mr. Redfield being on a journey to the western part of Massachusetts, happened to travel over a region covered by marks of the ravages of the recent storm. He was accompanied by his eldest son, then a young lad, who well remembers these early observations of his father, and the inferences he drew from them. At Middletown, the place of Mr. Redfield's residence, the gale commenced from the southeast, prostrating the trees towards the northwest; but on reaching the northwestern part of Connecticut, and the neighboring parts of Massachusetts, he was surprised to find that there the trees lay with their heads in the opposite direction, or towards the southeast. He was still more surprised to find, that at the very time when the wind was blowing with such violence from the *southeast* at Middletown, a *northwest* wind was blowing with equal violence at a point less than seventy miles distant from that place. On tracing further the course and direction of prostrated objects, and comparing the times when the storm reached different places, the idea flashed upon his mind that the storm was a *progressive whirlwind.* A conviction thus forced upon his mind after a full survey of the facts was not likely to lose its grasp. Amid all his cares, it clung to him, and was cherished with the enthusiasm usual to the student of nature, who is conscious of having become the honored medium of a new revelation of her mysteries. Nothing, however, could have been further from his mind, than the thought that the full development of that idea, would one day place him among the distinguished philosophers of his time. So little, indeed, did he dream of fame, that for eight or nine years after the first conception of his theory, he gave little attention to the study of the phenomena of storms, but was deeply engrossed in other enterprises which, although foreign to this subject, were alike evincive of his original and inventive turn of mind. Of these we may take a passing notice.

Before the scientific world, Mr. Redfield has appeared so exclusively in the character of a philosopher, especially of a meteorologist, that they have been hardly aware of the important services he has rendered the public in the character of *naval engineer*, particularly in the department of steamboat navigation. His attention was turned professionally towards this subject as early as the year 1820, when he became much interested in an experiment with a small boat propelled by an engine of new and peculiar construction, the invention of Franklin Kelsey, Esq., a townsman of his. Although the enterprize was not successful to the company, yet to himself it was not destitute of valuable results, as it was the occasion of his acquiring a more intimate

knowledge of the properties of steam, of steam navigation, and of ship building. On the ruins of that enterprize was erected another, which after some vicissitudes acquired a permanent success, and opened to him a sphere of professional labor which constituted ever afterwards the leading object of his life, as a man of business. Several disastrous steamboat explosions had spread alarm through the community and created a general terror of steamboats. Redfield was the first to devise and carry into execution the plan of a line of *safety barges* to ply on the Hudson between New York and Albany. The scheme was, to construct a passenger boat to be towed by a steamboat at such a distance from it as to avoid all apprehension of danger to the passengers. Large and commodious barges were built, fitted up with greater taste and luxury than had at that time been exhibited by steamboats. With these were connected two large and substantial steamers; and in the excited state of the public mind, these safety barges became great favorites with travellers, especially with parties of pleasure. But our countrymen never hold their fears long: a short interval of exemption from steamboat accidents ended the excitement, while the greater speed attained by the ordinary boats, and the lower fare, gradually drew off passengers from the safety barges, until they could be no longer run with profit to the company, and were abandoned. But the idea was not without profit, for it suggested to him the system of *tow boats* for conveying freight, which was established in the spring of 1826, and still continues under its original organization. The fleets of barges and canal boats, sometimes numbering forty or fifty, which make so conspicuous a figure on the Hudson river, were thus set in movement by Mr. Redfield, and for thirty years the superintendence of the line first established, constituted the appropriate business of our friend. In its management he employed unwearied industry, superior mechanical genius for contriving expedients, and a knowledge of both the science and art of steam navigation, such as was possessed by few men of business. Seldom have we seen the inductive philosopher so happily united with the practical engineer, each character borrowing aid from the other. Seldom has any one connected with the management of a steam navigation concern as his profession in life, carried into his business so much of the spirit of true science. No one else could have so thoroughly collected the statistics of the profession in this country, embracing all the facts relating to the explosion of steamboat boilers, as they successively occurred—the number of lives lost—the number of deaths by steam compared with those by lightning—and the number compared with those lost by other modes of travel. Moreover, while Mr. Redfield was diligently pursuing his daily

business and conducting with success the affairs of the "Steam Navigation Company," he was also engaged collecting facts for the improvement of the art itself, or for securing the safety of passengers. He devised simpler, cheaper, and safer forms of apparatus than those in general use. He investigated the influence of legal enactments for regulating steam navigation, and pointed out to legislatures and governments the inefficacy or inexpediency of such enactments, and suggested the true measures to be taken to promote the convenience and secure the safety of the public. He addressed a series of letters through the public prints to one of our prominent naval commanders, setting forth the adaptedness of steam as an agent of national defense. He responded to the call of the Secretary of the United States Treasury to point out the causes of steamboat explosions, and to suggest the means of safety. Happy would it be, if in all the great operations of the mechanical arts, the true spirit of the philosopher were so fully conjoined with the practical knowledge and skill of the engineer.

We turn now to another subject which engaged the attention of Mr. Redfield, and brought into exercise his remarkable sagacity and forecast. He was the first to place before the American people the plan of a system of railroads connecting the waters of the Hudson with those of the Mississippi. His pamphlet containing this project, issued in 1829, is a proud monument of his enlarged views, of his accurate knowledge of the topography of the vast country lying between these great rivers, of his extraordinary forecast, anticipating as he did the rapid settlement of the western states, the magic development of their agricultural and mineral wealth, and the consequent rapid growth of our great commercial metropolis. The route proposed is substantially that of the Erie railroad as far as this goes; but his views extended still further, and he marked out, with prophetic accuracy, the course of the railroads which would connect with the Atlantic states, the then infant states of Michigan, Indiana, and Illinois. These, he foresaw, would advance with incredible rapidity the settlement of those regions of unbounded fertility, and would divert no small portion of the trade from the Mississippi to the great metropolis of the east.

It must be borne in mind that railroads for general transportation were unknown in this country until 1826, when the project of constructing the Albany and Schenectady railroad was first entertained. As yet the advantages of railroads had not with us been practically demonstrated, and especially their advantages over canals were not generally understood or appreciated. At the moment when the Erie canal, having just been completed, was at the summit of its popularity, Mr. Redfield set forth in his pamphlet, under nineteen distinct heads, the great

superiority of railroads to canals, advantages which, although then contemplated only in theory, have been fully established by subsequent experience. He had even anticipated that after the construction of the proposed great trunk railway connecting the Hudson and the Mississippi, many lateral railways and canals would be built, which would bind in one vast net-work the whole great west to the Atlantic states. "This great plateau (says he) will indeed one day be intersected by thousands of miles of railroad communications; and so rapid will be the increase of its population and resources, that many persons now living will probably see most or all of this accomplished." How truly has this remarkable prediction, uttered in 1829, when there was not a foot of railroad in all the country under review, been fulfilled!

The motives which impelled Mr. Redfield to spread this subject before the American people at that early day, when railroads were scarcely known in this country, were purely patriotic. He had no private interests to subserve in the proposed enterprize, and the whole expense of preparing and publishing two editions of the pamphlet embodying these enlarged and prophetic views, was defrayed from his own limited resources.

In 1832, Mr. Redfield again issued a pamphlet, setting forth the importance of a railway leading from New York to Albany. This was no less evincive than the other of his public spirit and disinterestedness, since his private interests lay in the steamboat navigation of the Hudson, to which the proposed railway would be a powerful rival.

But we turn from these noble enterprises in which the philosopher and the engineer were happily united in the same individual, to the consideration of the great subject which, from this time, formed the leading object of his life, namely, to perfect his *theory of storms*. Nor do we turn away from great practical subjects to such as are merely speculative. The lives and property which Redfield's disinterested labors in behalf of steam navigation contributed to save, would, we believe, be of small amount compared with the sailors and ships which the rules founded on his theory of storms, when fully applied to practice, will save from shipwreck.

We have already seen that the attention of Mr. Redfield was first drawn to the subject of storms in the year 1821, by examining the position of trees prostrated by the great September gale, which passed over Connecticut and the western part of Massachusetts that year. Although he had never lost sight of the theory of storms, yet the multifarious business concerns which engrossed the greater part of his time for a number of years afterwards, prevented his bringing it distinctly before the public until the year 1831. I chanced at that period to meet him for

the first time on board a steamboat on the way from New York to New Haven. A stranger accosted me, and modestly asked leave to make a few inquiries respecting some observations I had recently published in the American Journal of Science on the subject of Hailstorms. I was soon made sensible that the humble inquirer was himself a proficient in meteorology. In the course of the conversation, he incidentally brought out his theory of the laws of our Atlantic gales, at the same time stating the leading facts on which his conclusions were founded. This doctrine was quite new to me, but it impressed me so favorably, that I urged him to communicate it to the world through the medium of the American Journal of Science. He manifested much diffidence at appearing as an author before the scientific world, professing only to be a practical man little versed in scientific discussions, and unaccustomed to write for the press. At length, however, he said he would commit his thoughts to paper, and send them to me, on condition that I would revise the manuscript and superintend the press. Accordingly, I soon received the first of a long series of articles on the laws of storms, and hastened to procure its insertion in the Journal of Science. Some few of the statements made in this earliest development of his theory, he afterwards found reason for modifying; but the great features of that theory appear there in bold relief. Three years afterwards he published, in the 25th volume of the same journal, an elaborate article on the Hurricanes of the West Indies, in the course of which he gives a full synopsis of the leading points of his doctrine, as matured by a more extended analysis of the phenomena of storms than he had made when he published his first essay.

Possibly some of our readers may not have fully acquainted themselves with Redfield's theory of storms, and would desire to be informed of its leading principles. I understand this theory to be substantially as follows:

That all violent gales or hurricanes are great *whirlwinds*, in which the wind blows in circuits around an axis either vertical or inclined; that the winds do not move in horizontal circles, as the usual form of his diagrams would seem to indicate, but rather in spirals towards the axis, a descending spiral movement externally and ascending internally.

That the *direction of revolution* is always uniform, being from right to left, or against the sun, on the north side of the equator, and from left to right, or with the sun, on the south side.

That the *velocity of rotation* increases from the margin towards the center of the storm.

That the whole body of air subjected to this spiral rotation is, at the same time, *moving forward* in a path, at a variable rate, but always with a velocity much less than its velocity of rota-

tion, being at the minimum, hitherto observed, as low as four miles, and at the maximum forty-three miles, but more commonly about thirty miles per hour, while the motion of rotation may be not less than from one hundred to three hundred miles per hour.

That in storms of a particular region, as the gales of the Atlantic, or the typhoons of the China seas, *great uniformity exists in regard to the path pursued,* those of the Atlantic, for example, usually issuing from the equatorial regions eastward of the West India islands, pursuing, at first, a course towards the northwest as far as the latitude of 30°, and then gradually wheeling to the northeast and following a path nearly parallel to the American coast, to the east of Newfoundland, until they are lost in mid-ocean, the entire path when delineated resembling a parabolic curve whose apex is near the latitude of 30°.

That their *dimensions* are sometimes very great, being not less than 1000 miles in diameter, while their path over the ocean can sometimes be traced for 3000 miles.

That the *barometer*, at any given place, falls with increasing rapidity as the center of the whirlwind approaches, but rises at a corresponding rate after the center has passed by; and finally,

That the phenomena are more uniform in large than in small storms, and more uniform on the ocean than on the land.

These laws Mr. Redfield claims as so many *facts* independently of all hypothesis; as facts deduced from the most rigorous induction, which will ever hold true, whatever views may be entertained respecting the origin or causes of storms.

The *method* adopted by the author of this theory, in all his inquiries,—the method which first led him to the discovery of the whirlwind character of storms, and afterwards fully confirmed the doctrine,—was first to collect and then to collate as many records as possible of vessels that had been caught in the storm, in various parts of the ocean. The most laborious and profound investigation of this nature of which he has left us an example, is in the case of the Cuba hurricane of October, 1844. First, he examined all accessible marine reports of vessels that had arrived in port after encountering the storm; secondly, he inspected the log-books of all such vessels, as far as was practicable, and carefully transcribed their records; and, thirdly, by an extended correspondence, he obtained a great number of written statements from shipmasters, who of all men would be the most accurate and vigilant observers. The different independent accounts obtained from these various sources amounted to no less than one hundred and sixty-four, all of which were reduced to the form of tables, containing the latitude and longitude of each vessel or place at the time of observation; the exact date and duration of the gale; the successive directions of the storm-

wind; the state of the barometer; and, finally, every additional particular that was deemed of the least importance in determining the peculiar characteristics of the storm. With these data before him, he spread out a marine chart, and having noted on it the position of each vessel and place with the direction and force of the wind, the plot itself proclaimed to the eye the whirlwind character of the storm; and the comparison of dates, and corresponding courses of the winds, and respective states of the barometer, showed the dimensions of the storm, its rotary and progressive velocities, its duration at any given place, and its various degrees of violence at different distances from the center. In the character of the researches before us, conducted as they were, not in the shades of philosophic retirement and learned leisure, but in hours redeemed from the pressing avocations of an onerous and responsible business, or borrowed from the season allotted to sleep, we trace qualities of mind that belong only to the true philosopher.

The benevolent and practical mind of Redfield had no sooner established the laws of storms, than it commenced the inquiry, what rules may be derived from it, to promote the safety of the immense amount of human life and of property that are afloat on the ocean, and exposed continually to the dangers of shipwreck; in this imitating our Franklin, who as soon as he had discovered the identity of lightning with the electricity of our machines, hastened to the inquiry, How may we so apply our knowledge of the laws of electricity as to disarm the thunderbolt of its terrors? We might pursue the comparison and say, that as every building saved from the ravages of lightning by the conducting rod, is a token both of the sagacity and the benevolence of Franklin, so every vessel saved from the horrors of shipwreck by rules derived from these laws of storms, is a witness to the sagacity and benevolence of Redfield. Other writers on the laws of storms, especially Reid and Piddington, have lent important aid in establishing rules for navigators, until it is now easy for the mariner by the direction in which the gale strikes his ship, to determine his position in the storm, and the course he must steer in order to escape from its fury. Nor are testimonies wanting of the successful application of these rules. The most accomplished navigators (we might instance particularly Commodores Rodgers and Perry, and Commander Glynn, of the U. S. Navy) have testified that within their knowledge and in some cases within their own observation, many ships have owed their deliverance from the perils of shipwreck to a faithful observance of the rules derived from Redfield's theory of storms. In no department perhaps of the studies of nature have mankind been more surprised to find things governed by fixed laws than in the case of the winds. It is now rendered in the highest

degree probable, that every breeze that blows is a part of some great system of aerial circulation and helps to fulfill some grand design. "Inconstant as the winds" has long been a favorite expression to denote the absence of all uniformity or approach to fixed rules; but the researches of the meteorologists of our times, force on us the conclusion that the winds, even in the violent forms of hurricanes and tornadoes, are governed by laws hardly less determinate than those which control the movements of the planets.

It has been often noticed in the history of science and the arts, that great discoveries and inventions spring forth simultaneously from different independent sources. Thus the discovery of oxygen gas, the greatest single discovery in chemistry, was made almost at the same moment by Priestley in England and Scheele in Sweden; and the method of fluxions, or the infinitesimal calculus, was invented at nearly the same time by Newton and Leibnitz. Such discoveries and inventions are the true resultant of innumerable forces, which at that moment, and never until then since the origin of time, all conspired. It is remarkable that the idea that great storms are progressive whirlwinds was, for the first time, embraced nearly at the same instant by Redfield and Dové, although the conclusion was arrived at by totally different methods of investigation. Mr. Redfield says in a note to his paper on the Cuba hurricane, published in 1846, that it was not until seven years after the publication of his theory of the rotary and progressive character of storms, that he became acquainted with the suggestions and opinions of Col. Capper, and with the particular views and elucidations published by Professor Dové in his paper on Barometric Minima found in Poggendorff's Annalen for 1828. To all who were personally acquainted with Redfield, it would be quite unnecessary to adduce any other evidence than his simple declaration, of the perfectly original and independent character of his theory of the laws of storms. But we might refer to the circumstances under which it was conceived, when he was far removed from all libraries, and all intercourse with the scientific world; and as respects Dové, in particular, whose essay was communicated to the public in 1828, it may be said, that at that period there was scarcely a copy of Poggendorff's Annalen, in which Dové's essay appeared, in the United States; and being in the German language, nothing could be more improbable than that its contents were then known to Redfield. In 1838, our friend found to his great joy a most able ally in Col. Reid of the Royal English Engineers, then stationed in the island of Barbadoes. The earliest inquiries of Col. Reid were based on a violent hurricane, which occurred in that island in the year 1831. Searching for accounts of previous storms, he met with nothing satisfactory until he fell in with

Redfield's earliest paper respecting the September gale of 1821, published in the American Journal of Science. With the view of testing Redfield's doctrines, he submitted to the closest scrutiny the records which the Barbadoes storm had left of its ravages,—an investigation which ended in a perfect conviction that this storm was a progressive whirlwind. A friendly correspondence was shortly afterwards opened between these two congenial spirits, which resulted in an intimacy unbroken except by the hand of death. Commodore Perry, in the recent Report of his Japan Expedition, thus expresses himself in an introductory note to Mr. Redfield's Essay (the latest of his published works) on the Cyclones of the Pacific, addressed to Commodore Perry, and forming a part of his volume. "It was my good fortune (says the Commodore) to enjoy, for many years, the friendly acquaintance of one as remarkable for modesty and unassuming pretensions, as for laborious observation and inquiry after knowledge. To him and to Gen. Reid of the Royal Engineers of England (now governor of Malta) are navigators mainly indebted for the discovery of a law which has already contributed, and will continue to contribute, greatly to the safety of vessels traversing the ocean. It is true that subsequent writers have furnished additional information on this subject; but to Redfield and Reid should be ascribed the credit of the original discovery of this undeniable law of nature and its application to useful purposes; and there can be nothing more beautiful, as illustrative of the character of these two men, than the fact, well known to myself, that notwithstanding their simultaneous observations and discoveries, in different parts of the world, neither claimed the slightest merit over the other, but each strove to give to his co-worker in research the meed of superior success in the great object of their joint labors; and thus, without ever meeting, a strong friendship was formed between them, growing out of congenial aspirations for an honorable fame, and mutual admiration of the generous and enlightened views exhibited by each other; and this ennobling feeling was kept alive to the last by friendly correspondence."

The idea of whirlwinds is indeed much older than Redfield or Reid, being as old as the writings of the psalmist and the prophets; and we safely admit further, that the doctrine of ocean gales being sometimes of a rotary character, had been hinted at by several writers, as hints of such a principle as gravitation had long preceded the investigations of Newton; but the honor of having established, on satisfactory evidence, the rotary and progressive character of ocean storms, and determining their modes of action or laws, it is due alike to the memory of the departed, and to our country's fame, to claim for WILLIAM C. REDFIELD.

Back of the laws that govern these ocean gales, as first determined by Redfield and confirmed by Dové, Reid, Piddington,

Thom, and other well known writers, lies a more profound inquiry, How are these laws themselves to be accounted for? What sets the storm in motion, and gives it the whirlwind character, and at the same time carries it forward, and in so definite a path? What makes it revolve always from right to left on the north side of the equator, and from left to right on the south side? Why does its violence increase towards the centre of the storm, and why is its force there so tremendous? Laws, it must be remembered are facts, and merely express the modes in which nature acts: they are themselves phenomena to be accounted for. To which of the ultimate causes of physical phenomena is their origin, in the present case, to be traced? Is it heat? Is it electricity? Is it gravity? Is it connected in some way with the grand system of planetary motion? Questions of this kind were pressed on Mr. Redfield from various sources by those who assailed his theory. At first he declined any attempts at their solution. He claimed that the whirlwind character of storms, and the laws which he had assigned to them, are matters of fact, as established not only by himself, but also by Reid, Milne, Dové, and Piddington; that never having attempted to establish a theory of winds, nor the origin or first cause of storms, he had no occasion to go into these inquiries, but had long held the proper inquiry to be, *What are storms?* not *How are storms produced?* He however incidentally, at different times, indicated his opinions on the ultimate causes of storms. Electricity, Redfield entirely rejected as an agent in the production of winds and storms, considering its presence and development rather as a consequence than as a cause of atmospheric changes. To heat he assigned only a limited and local effect, denying its agency in producing either the great and established movements of the atmosphere, or the extraordinary commotions which constituted the chief objects of his study, hurricanes and tempests. But he considered what he called the "dynamics of the atmosphere," as connected with and resulting from the diurnal and annual motions of the earth. While, from the first, I have heartily embraced Redfield's doctrine that ocean gales are progressive whirlwinds, and have further fully believed that he had established these laws or modes of action on an impregnable basis, a regard to truth and candor obliges me to say, that I have never been a convert to his views respecting the ultimate causes of storms, especially so far as he assigned for these causes what he denominates the "diurnal and orbitual motions of the earth," but his notions on this point have always appeared to me vague and unsatisfactory. Nor, while I have been impressed with the belief that *heat* is, in general, by far the most influential of all natural agents in destroying the equilibrium of the atmosphere, and of causing its motions, both in established currents, as the trade

winds and the monsoons, and in its violent commotions, as in hurricanes and tornadoes, yet I am compelled to think that but little progress has yet been made in determining its *modus operandi*, or in tracing the *connection* between changes of temperature and the actual phenomena of winds and storms:—why, for example, the Atlantic gales originate where they do, in the tropical regions—why they first pursue a path to the northwest as far as the latitude of 30°, and then gracefully wheel in parabolic curves towards the northeast, and pursue this course for the remainder of their way—why they revolve on their axes and always in one direction—whence they acquire so tremendous a force, especially towards the central parts—why the barometer is so low in the center and so high in the margin of the storm. These and various other points connected with the whirlwind character of storms, seem to me to have met hitherto with but a partial and doubtful solution. The laws constitute the true theory of storms: the rest is yet hypothesis.

Various writers have severally displayed great ingenuity and profound knowledge of atmospheric phenomena, in their endeavors to solve these problems, but with respect to the causes which lie back of the laws of storms, we still remain to a great degree in ignorance. Each of the combatants appears to me to be more successful in showing the insufficiency of the other's views than in establishing his own. With respect to him who is more particularly the subject of my remarks, whose logical powers I have always admired, I have almost regretted that he did not adhere to the ground he originally took, namely, that he had not undertaken to explain the reason *why* the winds blow, but only to show *how* they blow. So far was matter of fact: all beyond was hypothesis. His facts are impregnable: his hypothesis doubtful. The conclusions derived legitimately from these facts constitute the laws of storms; and being, as we believe, like the other laws of nature immutable, the name indissolubly associated with their discovery, acquires a fame alike imperishable. Redfield might therefore have safely stopped where Newton stopped. "Newton (says one of his biographers) stopped short at the last fact which he could discover in the solar system—that all bodies were deflected to all other bodies, according to certain regulations of distance and quantity of matter. When told that he had done nothing in philosophy; that he had discovered no cause; and that, to merit any praise, he must show how this deflection was produced; he said, he knew no more than he had told them; that he saw nothing causing this deflection; and was contented with having described it so exactly, that a good mathematician could now make tables of the planetary motions, as accurate as he pleased, and hoped in a few years to have every purpose of navigation and philosophical curiosity completely answered."

Various other contributions to science of our departed friend must, for want of space, be passed by with hardly a notice. Such are his published meteorological essays*—his reports of meteorological observations, which contain many original hints of much value—his paper on the currents of the Atlantic—and his researches in geology, which occupied much of his attention during the latter years of his life—all of which speak the skilful observer, the judicious philosopher, the lover of science, the lover of his country and of his kind. Three distinguishing marks of the true philosopher met in William C. Redfield—originality to devise new things; patience to investigate; and logical powers to draw the proper conclusions. The impress of his originality he left, in early life, upon the village where he resided; he afterwards imprinted it still deeper on his professional business, as naval engineer; and most of all on his scientific labors, his observations, and his theories. "Patient thought" was the motto of Newton, and in this attribute, Redfield was eminently distinguished. In collecting facts bearing upon his main purpose, and in submitting them to severe and long continued comparison, he has illustrated this quality in its highest forms, as his laborious investigation of the phenomena of hundreds of storms, most fully evince. Originality to invent without patience to investigate, leads to hasty and wild speculations; but united they lay the deep foundations for a severe logic. His powers of reasoning have always appeared to me to be of high order, and he has been fitly characterized by another eminent writer† on the laws of storms, as the "clear-headed" Redfield. Opinions which he had thus formed, after an extensive and patient investigation of the facts, and a severe process of reasoning, he held with great tenacity. But though firm, he was not obstinate. *Obstinacy* we define to be an unyielding adherence to our opinions because we have adopted them: *firmness*, a similar adherence to our opinions, because we believe them to be right.

Few men have given more signal proofs of an original inherent love of knowledge. Whether we contemplate the apprentice-boy after the toils of the day, seeking for knowledge by the dim light of an open fire; or the father of a young family, through dark scenes of domestic affliction and mournful bereavements, still adding largely year by year to his intellectual stores; or the man of business in the whirl of the great metropolis, loaded with onerous and responsible cares, giving every interval of leisure, and the seasons chiefly employed in pleasure or repose to the study of the laws of nature; or if permitted, as has been my privilege, to be a guest at the house fitted up to be the retreat of his old age, we see the library, the collections of natural his-

* Originally prepared for Blunt's Coast Pilot. † Reid.

tory, the many sources of high mental enjoyment, which in the period gained at last of ease and affluence, distinguish the different apartments of his dwelling; or finally whether we call to mind the ever increasing interest with which he attended the meetings of the American Association for the Advancement of Science, and the delight which he experienced in the society of learned men, we observe in all, a mind in love with truth, ever searching and ever expanding. In society he was courteous, sincere, upright, and benevolent; in his family, tender, affectionate, wise in council and pure in example; in all his walk and conversation, and especially in the church of God, a devout and humble christian.

As the evening of life was passing thus serenely, it hastened to a peaceful close. Mr. Redfield's health had been generally good during his later years, and had seemed particularly so in the early part of the winter which proved his last. On the first of January, he made his usual calls on his friends, and the cheerfulness and vivacity of his manners and healthful expression, were never more remarkable. Near the last of January he was seized with alarming symptoms, which indicated effusion in the chest. His disease made rapid and sure progress. The last book which had engaged his attention previous to his illness was Dr. Kane's recent Narrative of his Arctic Expedition, and his own feverish dreams, during the earlier nights of his sickness, were confusedly identified with the toils, the difficulties, and the sufferings of that heroic commander and his brave companions. With a general tendency to delirium were mingled intervals of calmness, and throughout his illness his countenance would light up with the smile of affection, as he recognized the relations and friends around him. From the first he entertained but slight hopes of recovery; but as the crisis drew near, his mind was at peace, and in calm resignation to the will of his Maker, and in the full exercise of christian faith, he gently breathed his last.

*List of the published papers of the late* Wm. C. Redfield.

1. Sketch of the Geographical Route of a great Railway, by which it is proposed to connect the Canals and navigable waters of the States of New York, Pennsylvania, Ohio, Indiana, Illinois, Missouri, and the Michigan, North West, and Missouri Territories, opening thereby a free communication at all seasons of the year between the Atlantic States and the great valley of the Mississippi. Pamphlet, published by G. & C. & H. Carvill, New York, 1829.

A second edition of the above, with an appendix of much additional matter, was published by the same house in 1830.

2. Remarks on the prevailing storms of the Atlantic Coast of the North American States. American Journal of Science, vol. xx, p. 17. April, 1831.

3. List of Steamboat Explosions which have occurred in the United States, with some remarks on the same. Am. Journ. Sci., xx, 336. July, 1831.

4. On the supposed collapse of Steam-boilers, and the means of preventing explosions. Amer. Journ. Sci., xxi, 190. Oct. 1831.

5. Note on the Hurricane of August, 1831. N. Y. Journal of Commerce, Sept. 28, 1831. Copied in Am. Jour. Sci., xxi, 191, Oct. 1831.

6. Facts and Suggestions relating to the New York and Albany Railroad. Pamphlet, New York, 1832.

7. Notice of American Steamboats. Amer. Journ. Sci., xxiii, 311, Jan. 1833.

8. Observations on the Hurricanes and Storms of the West Indies and the Coast of the United States. Blunt's American Coast Pilot, 12th edition, p. 626, July, 1833, and in subsequent editions; also in Amer. Jour. Sci., xxv, 114, Oct. 1833; translated in Bibl. Univ. de Genève, i, 412, 1834.

An Abstract of the above under the title of "Monitions and Instructions for vessels navigating on the western side of the Atlantic" is found in Purdy's Memoir upon the Atlantic Ocean, 10th edition, 1853, p. 303.

9. Summary Statements of some of the leading Facts in Meteorology. Amer. Journ. Sci., xxv, 122, Oct. 1833. Originally prepared for the American edition of "Million of Facts," published in New York, 1833. It constitutes the new matter under the head of "Atmospheric and Aerial Phenomena" in that work. Some copies have been circulated in pamphlet form under the title of "Facts in Meteorology."

10. Report of the Board of Examiners appointed by the Connecticut River Steam Boat Company to enquire into the Causes of the Explosion of the Steam Boat New England. Published by the Steam Boat Company. Dec. 1833.

11. Synopsis of a Meteorological Journal kept in the city of New York during the years 1833 and 1834. Report of the Regents of the Univ. of State of N. Y. for 1835. p. 183; Amer. Journ. Sci., xxviii, 154, April, 1835.

12. On the Evidence of certain Phenomena in Tides and Meteorology, (In reply to Notes of an Observer [Mr. Espy]). Journ. Franklin Institute, Phil., xv. 372, June, 1835; Amer. Journ. Sci., xxviii, 310, July, 1835.

13. On the Gales and Hurricanes of the Western Atlantic. London Nautical Magazine, v, 199, April, 1836; U. S. Naval Magazine, i, 301, July, 1836; Amer. Journ. Sci., xxxi. 115, Oct. 1836.

14. On the Whirlwind character of certain Storms, (In reply to Mr. Espy's No. 3, in a series of Meteorological Essays in Journ. of Franklin Institute). Journ. Franklin Institute, xix, 112, Feb. 1837.

15. Remarks on the supposed connection of the Gulf Stream with opposite currents. U. S. Naval Magazine, ii, 243, May, 1837; Journ. Franklin Institute, xix, 384, May, 1837; Blunt's Amer. Coast Pilot, 13th edition, p. 666, June, 1837, and in subsequent editions; American Journ. Sci., xxxii, 349, July. 1837.

16. Synopsis of a Meteorological Journal kept in the City of New York, during the years 1835 and 1836; reported to the Albany Institute. Report of Regents of Univ. of State of N. Y. for 1837, p. 214, March, 1837.

17. Cursory Remarks and Suggestions on various topics in Meteorology, by an Amateur Observer. Blunt's Amer. Coast Pilot, 13th ed., p. 689, and subsequent editions, June, 1837.

The same under the title of "Meteorological Sketches, by an Observer." Amer. Jour. Sci., xxxiii, 50, 261, Oct. 1837 and Jan. 1838; U. S. Naval Magazine, ii, 392, 1837.

18. Some account of two visits to the Mountains in Essex Co., N. York, in the years 1836 and 1837; with a sketch of the northern sources of the Hudson. Am. Journ. Sci., xxxiii, Jan. 1838; Family Magazine, N. Y., v, 345.

19. Notice of Fossil Fishes in Virginia. Amer. Jour. Sci., xxxiv, 201, April, 1838.

20. Synopsis of Meteorological Journal kept in the City of New York for the year 1837, including the average results of the last five years. Report of Regents, 1838 or 1839; Am. Journ. Sci., xxxiv, 373, July, 1838.

21. Letter to Lieut. James Hoskin, R. N., Commander of the Steamship Great Western, on the speed of Steamboats. N. Y. Journal of Commerce, Aug. 8, 1838; London Nautical Magazine, 1838, p. 673; Jameson's Journal, Feb., April, 1838.

22. On the courses of Hurricanes, with notices of the Typhoons of the China Sea, and other Storms. Amer. Journ. Sci., xxxv, 201, Jan. 1839; London Nautical Magazine, 1839, p. 1, Jan. 1839.

23. Genealogy of the Redfield Family in the United States. Printed for private circulation, March, 1839.

24. Some Account of violent columnar Whirlwinds which appear to have resulted from the action of large circular Fires, with Remarks on the same. (Read before the Connecticut Academy of Arts and Sciences, Jan. 22, 1839.) Amer. Jour. Sci., xxxvi, 50, April, 1839; Bibliothèque Univ. de Genève, 1840, xxviii, 432.

25. Additional Facts relating to the Raleigh's Typhoon of August 5th and 6th, 1835, in the China Sea. Amer. Journ. Sci., xxxvi, 59, April, 1839; London Nautical Magazine, 1839, p. 461.

26. Letter to the Secretary of Treasury of U. S. on Steamboat Explosions and their preventions, dated Dec. 26, 1838. Congressional Document, 25th Congress, 3d Session, House of Reps., Doc. No. 21, 1839; London Nautical Magazine, 1839, p. 617, 681 and 813.

27. Remarks on Mr. Espy's Theory of Centripetal Storms, especially his positions relative to the storm of Sept. 3d, 1821, with some notice of his examinations of other storms. Journ. Franklin Institute, xxiii, 323, 363, May and June, 1839.

28. Further notice of Mr. Espy's examination of Storms. Journ. Franklin Inst., xxiv, 1, July, 1839.

29. Account of the Circular Storm of Dec. 1839. Journ. of Commerce, Jan. 6, 1840; London Nautical Magazine, 1840, 424.

30. On the Causes of Steamboat Accidents and the practical means of preventing their occurrence. (Communicated by request through Capt. J. W. Pringle, R. E., to the Commissioners on that subject appointed by the English Government. Received too late for the Report of the Commissioners), but published here in "Appendix to a Memorial of Proprietors and Managers of American Steam-vessels on the impolicy and injustice of certain enactments contained in the law relating to steamboats." Jan. 1840.

31. Abstracts of Meteorological Observations made at St. John's, Newfoundland, and at Canton in China, with some notice of the Half-yearly Inequalities of Atmospheric Distribution which appear in these observations. Am. Jour. Sci., xxxviii, 265, April, 1840.

32. Synopsis of a Meteorological Journal kept in the City of New York for the years 1838 and 1839, including also the mean results of the last seven years. Report of the Regents of the University of State of N. Y., 1840; Am. Journ. Sci., xxxviii, 323, April, 1840.

33. Short Notices of American Fossil Fishes. (Read before the Yale Natural History Society.) Am. Jour. Sci., xli, 24, July, 1841.

34. Five Letters to Commodore Perry on the means of National Defence. N. Y. Journal of Commerce, July, 1841.

35. Remarks relating to the Tornado which visited New Brunswick in the State of New Jersey on the 19th June, 1835, with a plan and schedule of the prostrations observed on a section of its track. London, Ed. and Dub. Phil. Mag. and Jour. Sci., xviii, 20, Jan. 1841; Am. Jour. Sci., xli, 69, July, 1841; Jour. Frankl. Inst., xxviii (or 3d series ii), 40, July, 1841.

36. Observations on the Storm of Dec. 15th, 1839, with a Map showing the direction of the wind at noon of that day, as observed at various places. (Read before the Am. Phil. Soc., Jan. 15, 1841.) Lond., Ed. and Dubl. Phil. Mag., xvii, 17, July, 1841; Am. Jour. Sci., xlii, 112, Jan. 1842; Trans. Am. Phil. Soc., viii, new series, 77, 1843.

37. Extract of a letter to Sir J. F. W. Herschel. Report of 10th meeting of British Assoc. for Adv. of Science, 1841, p. 40, 1841.

38. Reply to Dr. Hare's Objections to the Whirlwind Theory of Storms. Am. Jour. Sci., xlii, 299, April, 1842; Lond., Ed. and Dubl. Phil. Mag., xx, 353, May, 1842.

39. Reply to Dr. Hare's Further Objections relating to Whirlwind Storms, with some evidence of the whirling action of the Providence Tornado of August, 1838. Am. Jour. Sci., xliii, 250, Oct. 1842; latter portion of the article also in Amer. Repertory of Arts and Sci., iii, 81, March, 1841; also in Jour. Frank. Inst., new series, iv, 252, Oct. 1842; first portion of article also in Lond., Ed. and Dubl. Phil. Mag., xxi, Suppl. 481, Dec. 1842; latter portion of article also in same, xxii, 38, Jan. 1843.

40. Notice of newly discovered Fish-beds and a Fossil Foot-mark in the Red Sandstone Formation of New Jersey. Am. Jour. Sci., xliv, 134, Jan. 1843.

41. Notice of Dr. Hare's Strictures on Prof. Dove's Essay on the Law of Storms. Am. Jour. Sci., xliv, 384, April, 1843; Jour Franklin Inst. for 1844, p. 384.

42. Remarks on Tides and the prevailing Currents of the Ocean and Atmosphere. (Read before Amer. Phil. Soc. at its centennial meeting, May 27th, 1843.) Am. Jour. Sci., xlv, 393, Oct. 1843; London Nautical Magazine, 1843, 655.

43. On the drift Ice and Currents of the North Atlantic, with a Chart showing the observed positions of the Ice at various times. Am. Jour. Sci., xlviii, 373, April, 1845; London Nautical Magazine, 1845, p. 298, 353; Blunt's Memoir on the Dangers and Ice of the North Atlantic.

44. Letters to the U. S. Board of Navy Commissioners, being replies to their circular asking information relative to Steam Navigation applicable to government purposes. Jour. Frankl. Inst., new series, x, 361, and xii, 1, June, July and Aug. 1846.

45. On three several Hurricanes of the American Seas, and their relation to the Northers so called of the Gulf of Mexico and the Bay of Honduras, with Charts illustrating the same. Am. Jour. Sci., new series, i, 1, 153, 333, ii, 162, 311, Jan., March, May, Sept. and Nov. 1846.

46. Effects of the Earth's Rotation upon Falling Bodies, and upon the Atmosphere. Am. Jour. Sci., new series, iii, 283, March, 1847.

47. Remarks on a Letter from R. N. Shufeldt of U. S. Ship Marion to E. and G. W. Blunt, relative to a Hurricane encountered by Ship Marion, Sept. 1848. London Nautical Magazine, 1849, p. 39.

48. On some Fossil Remains from Broome Co., N. Y. Proceedings of Am. Assoc. for Adv. of Science, 2d Meeting, 1849, (at Cambridge,) p. 255.

49. The Law of Storms and its penalties for neglects. N. Y. Jour. of Commerce, June 19, 1850; London Nautical Magazine, 1850, p. 470; Bermuda Royal Gazette, July 16, 1850; N. Y. Courier and Enquirer.

50. On the apparent necessity of revising the received systems of Dynamical Meteorology. Proc. Am. Assoc. for Adv. of Sci., 4th Meeting, (New Haven,) p. 366, 1850.

51. On the Post-Permian Date of the Red Sandstone Rocks of New Jersey and the Connecticut Valley, as shown by their Fossil Remains. Proc. Am. Assoc. for Adv. of Science, 5th Meeting, (Cincinnati,) p. 45, May, 1851.

52. On the Fossil Rain-marks found in the Red Sandstone Rocks of New Jersey and the Connecticut Valley, and their authentic character. Proc. Am. Assoc. for Adv. of Science, 5th Meeting, (Cincinnati,) p. 72, May, 1851.

53. On the value of the Barometer in navigating the American Lakes. Proc. Am. Assoc. for Adv. of Science, 7th Meeting, (Cleveland,) p. 54, 1853; Wells's Annual of Scientific Discovery for 1854, p. 200.

54. A storm-track of Seven Thousand Miles. Annals of Science, Cleveland, vol. ii, p. 47, 1854.

55. Cape Verde and Hatteras Hurricane and other Storms, with a Hurricane Chart. Proc. Amer. Assoc. for Adv. Sci., 8th Meeting, (Washington,) p. 208, 1854. This paper and the preceding are abstracts of the following.

56. On the first Hurricane of September, 1853, in the Atlantic, with a Chart, and Notices of other Storms (Cape Verde and Hatteras Hurricane). Am. Jour. Sci., new series, xviii, 1, 176, July and Sept. 1854; London Nautical Mag., 1854, p. 466, 526, 597, Sept., Oct., Nov. 1854.

57. On the Storm of October 7th, 1854, near the coast of Japan, and the Conformity of its progression with other Cyclones. Proc. Am. Assoc. for Adv. of Sci., 9th Meeting, (Providence,) Aug. 1855, p. 183.

58. On the relations of the Fossil Fishes of the Sandstone of Connecticut and other Atlantic States to the Liassic and Oolitic Periods. Read before the American Assoc. for Advancement of Science, Albany, Aug. 26, 1856. Am. Jour. Sci., new series, xxii, 357, Nov. 1856; Proc. Am. Assoc. for Adv. of Sci., 10th Meeting, Albany, p. 180, 1857.

59. On the Spirality of Motion in Whirlwinds. Am. Jour. Sci., new series, xxiii, 23, Jan. 1857.

60. *Notes* attached to a Communication "On the Avoidance of the violent portions of Cyclones, with notices of a Typhoon at the Bonin Islands," (by John Rodgers, Commander U. S. N., and Anton Schönborn, Assist. Ast.) Am. Jour. Sci, new series, xxiii, 205, March, 1857.

61. On Pacific Cyclones. Am. Jour. Sci., xxiv, 21, July, 1857. An abstract of the following.

62. Observations in relation to the Cyclones of the Western Pacific, embraced in a Communication to Commodore Perry. Perry's Japan Expedition, ii, 335, July, 1857.

ART. XXVII.—*Observations on the Zodiacal Light at Quito, Ecuador, with deductions;* by Rev. GEORGE JONES, Chaplain U. S. Navy.*

THE deduction which I drew from observations made on the Zodiacal Light while engaged on the Japan cruise, namely, that there is a great nebulous ring having the earth for its centre, has been variously received; but I believe it is now beginning to be, among the astronomers of this country, an admitted fact. The book containing my detailed observations has gone abroad so recently that we have not yet had time to hear how the subject has been received in Europe. There have been some opinions advanced antagonistic to my conclusions (one of them an article in this Journal) to which I have made no replies: for I do not intend to be drawn into controversy, but to rely quietly on the facts of the case to do their work of conviction in the minds of thinking men.

In the Introduction to the 3d vol. of the Report on the Japan Expedition I intimated my intention to spend a year, if possible, at or near the equator; and to procure there additional data on this subject, of which I felt greatly the need. It is customary, when an officer has returned from a long cruise, to give him some time on "leave of absence:" which custom I pleaded with the Navy Department, when I had finished bringing out my volume of the Japan Report; and thus I obtained permission to be absent from the country, on my own business, for a year. My desire was to proceed to Quito, where, in its proximity to the equator and in the transparent atmosphere of its great altitude, I hoped to have peculiar advantages for my work. At the equator, an observer must have the ecliptic vertical to him, at some hour or other, every night throughout the year; and it must at all hours, have an angle with the horizon sufficiently high to show the Zodiacal Light to the very best advantage. My hope was to be able to ascertain exactly the position of this nebulous ring in regard to the ecliptic: I had a faint hope also,—a very slight one,—of being able to learn something about the nature of nebulous matter—which, in astronomical science, may now perhaps be considered the greatest question of the age.

Before starting on this expedition I prevailed on Mr. Edward C. Herrick of Yale College, who had previously had much experience on this subject, to agree to make observations in New Haven, on the 1st, 10th and 20th of each month, and to record them on star-charts left with him for that purpose, and, soon after, succeeded in enlisting in the same cause Professor Moesta, Superintendent of the National Observatory at Santiago, Chile;

* Contributed to this Journal by the special request of the Editors.

Prof. M., who was furnished with charts, agreeing to make observations simultaneously with those of Mr. Herrick. Both of these gentlemen entered readily and cordially into the work: and I was able also, on the way to Ecuador, to join to our corps of observers a valuable coadjutor in Dr. Drayton, U. S. Navy, then attached to the sloop-of-war St. Mary's, stationed at Panama.

Quito is much troubled with clouds and rains. Nine months in the year are rainy; and only June, July and August are usually favored with clear skies: sometimes the clouds and rains continue through all the year. I was detained at Washington on duty till July: was then kept two weeks at Panama waiting for the English steamer to proceed south: a friend accompanying me was taken sick with the Panama fever and died on board the steamer: other passengers were dying when we arrived at Guyaquil; and we were ordered off without being permitted to land. Consequently I was not able to reach Quito till the close of August; from which time on, during all my stay of eight months on the Cordilleras, I had to contend unceasingly with the clouds. The work of observing was most laborious: for the clouds, in that region, come and go, without a minute's warning, forming suddenly in the sky without apparent cause, and in the same mysterious manner presently leaving it perfectly clear. Sometimes, while tracing the boundaries of the Zodiacal Light by a cluster of stars, I would find the cluster in a moment blotted out by some imperceptible agency, while all around it would be clear and bright: a few minutes' waiting would show it again in all its brightness; the vapor not having floated away, but having vanished as suddenly and as strangely as it had come. All this makes an observer's life there an anxious and watchful one. But when the sky is clear, it is a superbly glorious sight, such as I have never beheld in any other part of the world. The heavens are then fairly crowded with the smaller stars: and the Milky Way has a brightness and an apparent proximity wonderful to behold. It is to be lamented that there is not an observatory, with good telescopes, at that place. The government of Ecuador, unable to accomplish such a work itself, would be glad to see it done, and would furnish every facility that its means will allow.

I found there, that every thing distinctive in any celestial phenomenon, was brought out with a distinctiveness I had never before witnessed. Soon after reaching these altitudes, on going out, about midnight, to see whether I could find the Zodiacal Light over both horizons, as I had done when under peculiarly favorable circumstances in other parts of the world, I saw this light not only over the horizons but also *quite across the sky*. It formed a complete arch, passing near my zenith from the east to west; and was most distinctly and decidedly marked—looking as if a belt of thin white gauze were drawn across the heavens—

being clearly visible, but still not perceptibly dimming the stars beyond. My eye soon became accustomed to tracing it: and, from that time on, I never failed to see this luminous arch, at every hour of the night, when the moon or clouds did not prevent. I soon perceived that a cross-section of it would not present the same intensity of light quite across: but that it was brightest at its central part or central longitudinal line, dimming thence towards the edges or boundaries, which latter I sometimes found it difficult to make out. At the central part (running lengthwise) the line of strongest light was so well marked that I soon began to draw it on my charts, where I consider it fully reliable, showing both the inclination of this arch or ring to the ecliptic and the places of the nodes. As a proof of its clearness of marking among the stars, I may mention, that on the three different occasions, when other persons who had never before noticed the Zodiacal Light came to observe with me, and I said to them merely, "You see that luminous arch up in the sky:" "you see that, at its central part, the light is brighter than in any other portion: now I want you to tell me by what stars that brightest part passes," they never hesitated at once to give me the place of that strongest light, and to give it almost or quite exactly where I was in the habit of drawing it myself. So they did also with the boundaries of this luminous arch. Sometimes the light did not pass, by a regular dimming from this central line to the boundaries; but there was on each side a sudden offset or decided dimming about half way from it to the outer limits, whence it dimmed gradually again to the boundaries. I have repeated markings of this offset on my charts. It will be readily seen that I was not only, once every night, on the ecliptic; but was, six hours from that, at a distance of 23 or 24 degrees from that line: when this occurred towards the south, there was, on that side of the arch, beyond its usual boundaries, a faint and very dim light, as if I was then looking laterally at the nebulous ring. I did not ever notice this on the northern side. The light of this luminous arch was, at midnight, of a uniform character from one horizon to the other; a cold, white light, exactly like that of the Milky Way: and the arch had at that hour an uniform width the whole way across except at the horizons, where it widened out slightly; the nebulous substance at those lower extremes doubtless giving me reflected light, by which its outer edges of very diffuse matter were visible to the eye. This last sentence will convey to the reader's mind the idea that I did not consider the whole of this luminous arch as being reflected light: and I certainly, at an early stage of my observations on the Cordilleras, did begin to query whether this nebulous ring was not giving me light independently of the sun: that is—whether it was not self-luminous! My reasons for suspecting

this arose from the great difference in color between the light near the horizon adjoining the sun, whether in the evening or morning, and in the other portions of the arch: and also from the most decided manner in which the former, which was evidently reflected light, usually turned towards me, whatever my position might be, but especially when I was farthest from the ecliptic: while the other portions of the Luminous Arch, though siding over towards me at my farthest removes, were influenced in a far inferior degree by my change of place. The light at the horizon next the sun, except in the middle hours of the night, was always a warm yellow light, such as it ordinarily has in our own latitudes: while in all other parts of the arch it was a cold, white light, exactly like that of the Milky Way. Indeed not only was this arch in color like the galaxy, but its brightness was often so great that the notes to my observations in the deep hours of the night several times say that it looked much like another Milky Way stretched across the sky.

One evening, while I was standing on the hill Ychinbía near Quito, at the summit of which my observations were made, I watched the sun's last rays on the snow-covered top of the distant Cayambi, a mountain scarcely inferior in elevation or grandeur to Chimborazo itself. All around me had, for a long while, been in shadow: the sun had set to the lofty peaks of Pichincha opposite to me, but still lingered on Cayambi, lighting it up with a yellowish hue: suddenly, the yellow light ceased, and the snow of Cayambi took a white color that chilled me to look at. I was struck with the great resemblance of this yellowish hue to that of the Zodiacal Light as seen over the horizons just after nightfall or before daybreak: while the subsequent white color exactly resembled that of the other portions of the Luminous Arch; or, in the dark hours of the night, of the whole of it, stretched across the sky.

The question agitating my mind in all these observations was an interesting one: for, if this white light was not reflected light but was an independent light, then we have ascertained a most important quality of nebulous matter: it must be self-luminous.

I could not, at any time, discover an interruption or break in the light of this luminous arch, such as might be produced by the shadow of our globe. I tried, first, without having ascertained exactly where such a shadow ought to fall, so as to avoid any self-deception on the subject; but I could see no shadow: then I noted, carefully, on the charts where the sun's opposition would fall, but still there was no shadow to be made out. A German observer—I believe it is Theodore J. C. A. Brorsen,—who has seen this luminous arch repeatedly in Germany, says that the place opposite the sun was always brighter than any other part: I could never see any thing like that; the arch, to

my eye, having a pretty uniform character quite across, except the yellow part at the horizons as already noticed. This yellow light, in a good sky, just after nightfall or just before day-break, would extend as high as my zenith, where it would imperceptibly change into the cold white light. In the former cases, it had the distinctions which I have made in my printed volume, of a great effulgence at the centre and the lowest part, and of a diffuse light without this: I sometimes thought that these parts were brighter than I had ever seen them at the level of the sea: but at Panama, on my way home, I witnessed such a splendid exhibition of Zodiacal Light as rather to make me change my opinion. I ought to add that, on this homeward journey, I saw this Luminous Arch, while at the level of the sea, at Payta, at Panama, off Jamaica, and off the northeastern end of Cuba. My eye by that time had become so experienced as easily to make it out in each of those places; and when, at Payta and at Panama, I pointed out this arch to others, they had no difficulty in, at once, making it out, and in giving me the places among the stars, of the central line and of the boundary on each side. I have little doubt that a person experienced in tracing it on the sky will be able to make it out in our own latitudes—say as far north as New York, in the evening in March. Brorsen informs us in the *Astronomische Nachrichten*, No. 998, that he has seen the Zodiacal Light quite across the sky repeatedly at Septenberg in Germany: Baron Humboldt saw also a portion, if not all, of this Luminous Arch in 1803 in lat. about 13° N. (see *Astron. Nachrichten*, No. 989): and I must have seen it repeatedly in my cruise in the Mississippi—for which see Report of Japan Expedition, vol. iii, pp. 55, 65 and 85, in all of which instances I was at a great distance from the ecliptic.

I had also at Quito one good exhibition of Zodiacal Light from the moon, the moon then being $1^d\ 1^h$ past full: also, on one occasion, at 9 30, had simultaneously the Zodiacal Light in the west from the sun and from the moon in the east, just before the rising of the latter: this light over at the east and west horizons being connected above by the Luminous Arch. I hope soon to be able to publish all the observations, 123 in number, made in this visit to South America: and also those of Mr. Herrick at New Haven and Prof. Moesta at Santiago in Chile made at the same time. But few of Prof. Moesta's have yet been received; but, both these and Mr. Herrick's sustain the conclusion in my published book, that, when the spectator is north of the ecliptic, the main body of the Zodiacal Light is north of that line: and south, when he is on its southern side.

The plate No. 7 accompanying this article is made up from the result of all my observations on this occasion. The full line *cccc*, on the chart, will show the course of the centre or the

strongest light of the luminous arch. The lines *aaaa*, *aaaa*, show its boundaries: the line *bbb*, the boundary of the very dim light seen occasionally while I was at my farthest remove from the ecliptic on its southern side. The diagram A on the chart is intended to show the comparative intensity of the light across the Luminous Arch: this intensity being according to the distance of the line *ddd* from *ee*. At B is another diagram in which the intensity is shown when the offset noticed above was seen;—the depth of the line *fff* from *gg* showing the relative brightness of the several parts. As to the actual brightness of this Luminous Arch, the following notes from my journal of observations may be satisfactory to the reader.

Oct. 7th, 1856. $0^h\ 20^m$. "The Luminous Arch at *m** has the brightness of the Milky Way at *n n*." [My zenith was 2° from the line *cc*.]

Oct. 29th, at 9 30. "I compared the brightness of the Luminous Arch with the Milky Way and thought that at *o* it was fully as bright as the latter at *ppp* (quite a bright part of the galaxy) perhaps even at *r*." [The ecliptic was vertical—the sky remarkably fine for observations.]

Dec. 2d. $11^h\ 30^m$. "Compared the light with that of the Milky Way, and thought that the part *s* of the Luminous Arch was equal in brightness to that of the Milky Way at *s'*." [The night remarkably fine: my zenith 24° S. of *cc*.]

Dec. 26th, $7^h\ 10^m$. "I thought the light of the Luminous Arch at *s* was equal to that of the Milky Way at *t t*, which is a tolerably bright part of the galaxy." [Sky fine for observations: my zenith 6° S. of *ccc*.]

Dec. 27th, $0^h\ 45^m$. "The brightness at *u u u* I thought equal to that of the Milky Way at *v v* on the chart: [my zenith was 28° S. of *ccc*.]

Feb. 3d, 1857, $4^h\ 45^m$. "I thought the Luminous Arch at *w w* equal to that of the Milky Way at *x*: not quite so bright as at *y*."

Feb. 4th, $3^h\ 20^m$. "I thought the light of the Luminous Arch from *w* to *z* was equal to that of the Milky Way at *y*. [My zenith 7° S. of *ccc*.]

Feb. 18th, $10^h\ 45^m$. "Thought the light at $m^1$ was equal to that of the Galaxy at $n^1$: at $m^2$ it was equal to that at $n^2$."

Feb. 24th, $9^h\ 20^m$. "The light along the central part of the Luminous Arch from $m^3$ to $m^4$ was equal to that of the Milky Way at $n^3\ n^4$:" [my zenith 24° S. of *ccc*.]

The Luminous Arch usually remained visible in the zenith and the western part of the sky some time (occasionally 15 minutes) after dawn had decidedly come at the eastern horizon.

I had also observations of other very interesting phenomena in the heavens and the atmosphere: but, though they are *akin* to this topic, I do not consider it best to introduce them here.

The data which we now possess on the Zodiacal Light, seem to lead inevitably to the following conclusions.

§ 1. *That this light is from a great nebulous ring.* If there were no interruption from the moon or from clouds, this Luminous

* See the accompanying star-chart.

Arch was seen, all through the night, spanning the sky. To give only one example of this kind: on the night of the 26th–27th December, 1856, I had five observations; namely, at $7^h\,10^m$, $9^h$, midnight, at 3 and at $4^h\,45^m$, mean time. In each of these, the arch was complete across the heavens; so that each observation overlapped the other considerably. The western horizon, when I began observing, was only 17° 15′ from the sun: and the eastern, at my last observation, was but 19°: so that, during this night, with the exception of 36° 15′ at the sun, the whole circle was complete—its entire completeness being prevented only by the sun's superior light. Doubtless the same thing would have occurred every night, but for the moon and clouds.

§ 2. *This is a geocentric ring.* The parallelism of the boundaries of this Luminous Arch at all hours of the night seems to be conclusive on this point. During the nine months of observations the outer boundaries kept their parallelism all through the night, as the eastern skies rose, and as one portion of the heavens after another came into view, or, in the west, was lost to sight; which could be the case only on the supposition of a geocentric ring. If we make it heliocentric, it must be within or without our earth. If within, then we should not be able to see this light at all at midnight: if without, and the observations were just after nightfall, or before dawn, then we should have the end next the sun at a distance of 170 or 190 millions of miles, while the opposite end would be comparatively quite near to us: in which case, by the laws of perspective, the portion towards the sun would be narrowed down almost or quite to the vanishing point, while the part opposite to it, or next to us, would be of a great width; all which is contrary to fact as witnessed in these equatorial observations, and is also the very opposite to fact as the Zodiacal Light is seen in latitudes distant from the equator. At New York the Zodiacal Light appears as a cone with its wide part resting on the horizon, and its apex towards the zenith: but if we suppose it to be from a heliocentric ring, its apex should be at the horizon and its broad part high up in the sky.

In the 3d volume of the Japan Expedition Report, I have noticed the laws of reflected light as shown by Bouguer: but I must be allowed to introduce them here again, as in my new observations I studied the aspect of the skies with a particular reference to this subject, and with, as I thought, decisive results. It is a well known fact in optics that the larger the angle between the lines of incidental light and of light reflected from any object, the larger is the quantity reflected: and Bouguer has given a table with the number of rays out of a thousand, reflected at various angles from 0 up to 179°. In the diagram on Plate No. 5, of a heliocentric ring, E being the earth, and AB

the horizon $1^h\ 20^m$ after sunset, the angle between the incident ray from the sun to B and the reflected ray BE will be 15°; between the incident ray to F, and EF will be 25°; at H the angle is 36°; and higher up, at I it is 45°; and at K it is still larger. Thus the angles between the incident and reflected rays go on increasing from the horizon up to K. The table of reflected rays which Bouguer has furnished us as the result of his experiments shows but little difference of the amount of light reflected, where the difference in angularity is so small, as in these cases; but supposing that there is no difference at all and that the light is equal from B to K, this would be in opposition to the facts of the case, which are uniformly that the Zodiacal Light is very strong, often quite effulgent at B, and goes, losing its intensity as it ascends towards the zenith of the spectator. The fact is most clearly obvious, that the Zodiacal Light requires, by the laws of reflection, an hypothesis which will give us the angle between the incident and reflected light, at B greater than at F; at F greater than at K, and so diminishing upward; which is done, as we shall presently see, by a geocentric ring: a heliocentric ring must always give us the very reverse of this. This latter and long admitted theory would give us only a Zodiacal Light wide at the zenith and tapering to a point at the horizon next the sun: and moreover brightest above, and losing its brightness as it approaches towards the same horizon: both of which are utterly contrary to facts.

In Plate No. 5, we see what the shape of this Luminous Arch in the figure AKIB, BDC would have to be, if the ring were heliocentric; AB being the horizon just after nightfall or before dawn. The part B of the Zodiacal Light towards the sun would be extremely narrow, almost or quite a vanishing point, while the part at A would have the width AC—which we may suppose to represent the breadth of the nebulous ring.

The annexed Plate No. 6, will help to show how these laws of reflection, as drawn out in Bouguer's tables, apply to a ring having the earth for its centre; and how completely, in this case, they coincide with the facts of the Zodiacal Light, as exhibited in any latitude. The reader, if he is not familiar with this phenomenon may test the subject by using Prof. Olmsted's plate of the Zodiacal Light in the volume of the Am. Journ. of Science for 1851, p. 309, which is a fair exhibition of the Zodiacal Light in high northern latitudes; at the equator the application of these laws of reflection is much more striking and decisive.

In this plate, the inner belt BE, HI, AK, may be considered as representing the Luminous Arch presented to the eye. If AB be the spectator's horizon an hour and twenty minutes after sunset—say at $7^h\ 20^m$, then CI*m*, BH*m* may represent the shape of the Zodiacal Light as usually shown in latitudes somewhat

removed from the equator. At Quito I had the portion CI as represented here, from causes hereafter explained; above I the Arch had a uniform width across to the horizon at A. As the night wore round and the western horizons changed to F, D, H, and finally to J, &c.—the opposite end of the Luminous Arch would change from A, to *b*, *c*, *d*, *e*, and finally to *f*: so that during the night the whole circle would be seen, except B*f*, which if the diagram here were entirely symmetrical* would be seen to be equal to 40°. The dotted lines S, S′, S″, &c., represent the sun's rays, and the angles S′BO, S″FO, S‴DO, &c., will be the angles between the incident and reflected rays, the spectator being at O. The following table will represent the value of these angles, and will show, according to Bouguer's tables, the number of rays reflected to the eye out of every thousand incident rays.

| Angles—degrees. | | Rays reflected from smooth water. | Rays reflected from plate-glass not quicksilvered. |
|---|---|---|---|
| S′BO, | 161 | 343 | 422 |
| S″FO, | 146 | 184 | 270 |
| S‴DO, | 131 | 101 | 162 |
| S⁗HO, | 116 | 59 | 105 |
| S⁗⁗ at midnight, | 90 | 18 | 25 |
| S⁗⁗*m*O, | 67 | 18 | 25 |

The harmony between either of these columns of reflected rays, and the intensity of the Zodiacal Light from the horizon upward, is very remarkable. We do not know fully what nebulous matter is; but we may reasonably conclude that the laws for reflection of light, which Bouguer has discovered to apply to all other substances, apply also in this.

In my late observations, this Light was always brightest at the horizon and always brighter the nearer my horizon was to the sun: I studied it, night after night, with reference to these laws of reflected light, and constantly with an increasing conviction that a geocentric ring is the only one that could admit the phenomena presented to my eyes.

§ 3. *The position of this ring as regards the ecliptic.* In deciding upon this point, I shall be governed by the central line, or line of strongest light; and this was usually pretty well marked on the sky; so decidedly marked that the three gentlemen whom I have already spoken of as having been suddenly added as observers, had no hesitation in immediately stating its position among the stars, although they had never before noticed this Luminous Arch; and had now received no further aid from me, than to direct their attention to it, and to ask them to observe that the central part was the brightest portion of all. Since the whole of this arch followed slightly in my direction, as I was carried in a single night by the axial motion of the earth to the north or

* It is not so, the earth being disproportionately large.

south of the ecliptic, it is obvious that to get the position of this central line correctly, it ought to be observed only when it is nearly or quite vertical to the spectator. The average of all my observations, when I was at 2° or less from it, place it at its furthest extent on the south at 3° 10′ from the ecliptic. On the northern side I had but one observation of this kind, which made it 3° 30′ from the ecliptic. From this we may conclude that this central line; and therefore, as the outer boundaries always kept pace with it, that this great nebulous circle, makes an angle of 3° 20′ with the ecliptic.

My first observations of this central line placed the ascending node in longitude 62°; but subsequent ones made it vary from this down even to 42° of longitude: and the place of this crossing of the ecliptic seemed always to me to be very uncertain. But it was not so with the descending node, which every night's observation of that part of the sky showed at once to be near $\beta$ Scorpii, in longitude 242°. All the three observers already adverted to, dictated this line to me as passing by the twin stars at that place, and I think we may accordingly consider the longitude of the nodes as at 62° and 242°.

§ 4. *The distance from the earth and the width of this ring.* The manner in which that portion of the Zodiacal Light which was obviously reflected light, was turned in my direction when I was at my farthest removes from the ecliptic, was, on most occasions, very remarkable. Sometimes it appeared to have little affinity with my change of position; but at others this warm, yellow light over the horizon was deflected towards me in a most decided manner, showing that the substance from which it was reflected could not be at any vast distance, most certainly not at the distance which a heliocentric ring would require it to be. For, my removes from the ecliptic could never be greater than 1421 miles: and a light affected so decidedly by so small a change in the observer's place could obviously not come reflected from a medium at twice the distance of the sun.

Some approximations towards the actual distance of the ring may perhaps be gained by noticing how the central line of strongest light was affected by my changes of place. This line always changed with me, going in the direction in which I was carried, which of course is the very opposite of parallax: and we must despair of having any parallax in Zodiacal Light. This central line varies very much on my charts, even when I was in the same positions; for it was extremely difficult to mark accurately an object oftentimes so uncertain; and my aim was, not uniformity, but to record facts as they appeared to my eyes. There are, in consequence, discrepancies among my lines. But still these facts admit of classifications, from which general deductions may be drawn. For example, my records from Feb.

15th, 1857 to May 23d, show me, by the diurnal revolution of the earth, in positions at the times of observation, from 23° 15′ N. to 19° 45′ south of the ecliptic, making a distance of 2580 miles. Taking all my observations during this period, north of 18° N. of the ecliptic, and noting the average of the positions of the central line for these observations: and then all south of 18° S. of the ecliptic, with also the average of the positions of the central line for these, I find that the central line is affected to the extent of 1° 45′ by these my changes of place: that is, supposing the average of the northern positions to have been 20° N. of the ecliptic, and those of the southern 20° S. of it, my change from one to the other, amounting to 2400 miles, produced a change in the central line of 1° 45′; not a parallax, but *towards* me as my place was changed. In my observation of the 7th March at 4 50 A. M. I was 19° 30′ N. of the ecliptic: in another at 9 P. M. of the 19th of that month I was 20° S. of that line, making a difference of 2370 miles between these two positions: the central line of the Luminous Arch shows a change in these two observations of $2\frac{1}{2}$ degrees; that is, as I went from north to south 2370 miles, the central line went with me southwardly $2\frac{1}{2}$ degrees. I should however prefer the former result of 1° 45′ for 2400 miles, the average of many results being more reliable than that of a few. From this, calculations may perhaps be made that will give us the proximate distance of this ring from the earth.

Another observation bearing on this was the one I had of a moon's Zodiacal Light on the 14th October, 1856—one day after the moon had become full. I have not the slightest doubt that it was Zodiacal Light produced by the moon. It was a strong, full light, with all the characteristics of this light when produced by the sun, except that this was white, and wanted the warm tinge of the Zodiacal Light from the sun. I took outlines of it, commencing at $6^h\,40^m$ mean time and ending at $6^h\,54\frac{3}{4}^m$; the moon being hid, for a while, by a cloud on the horizon. This light, pale and strong below, was merged above in that of the Luminous Arch. If the full moon gives us a Zodiacal Light, then the ring must obviously lie between that satellite and our earth.

§ 5. *The width of this ring.* My observations on this subject also show discrepancies which it is not easy to reconcile. During the first two months of my residence on the Cordilleras, the width of the Luminous Arch as recorded on my charts is about 20°; in November it increases to 30°; from Feb. 18 to May 23, the average of widths is 33° 58′; the average of the whole amount of my observations is 25° 56′ for the width. At any one night it had a uniform width quite across, except at the horizons. The increase of width in the whole number of observations is probably owing to the fact that my eye, becoming more experienced in

observations of the Luminous Arch, was able to trace out, better, its dimmer markings on the sky. We may perhaps estimate, with safety, the width of the Luminous Arch as decidedly given to the eye, 30°: but doubtless the nebulous matter of this ring extends beyond that; of which we have proofs in the much greater width of the Zodiacal Light near the horizons, where the sun, bringing the very diffuse matter at the edges into vision, shows us what the eye in other parts of the arch was not able to detect.

As respects the singular offset, or sudden change of brightness repeatedly noticed within the outer boundaries, as if there might be two rings, the one nearer to us and of greater brightness than the other, I will not venture an opinion, with the slight data now in my possession. The offset was not always perceived; but, when seen, was of so decided a character as scarcely to leave any doubt of its reality. This inner ring, as I will call it for sake of distinction, had an average width of 14° 54′.

The very dim light frequently seen beyond the usual boundary on the south when I was at my furthest removes from the ecliptic in that direction, seems also scarcely to admit of a solution, with our present knowledge of the subject. This dim, lateral light has, on my charts, a remarkable uniformity of breadth; never less than twenty-three or greater than twenty-seven degrees. The reader will remark that I saw it only on the southern side of the Luminous Arch.

§ 6. *The amount of matter* in this nebulous ring must be prodigiously great. Estimating its width at 30° and its distance from us at 100,000 miles, its width would be 52,600 miles: its thickness must, at present, be a subject only of conjecture: but at any thickness which dynamics will admit of, the amount of material there must be immensely great. It will be remembered that the width, 30°, is only that of the Luminous Arch as presented to the eye: beyond its borders, there seems still to extend nebulous matter too diffuse to be seen except by the power of the sun.

§ 7. The last sentence above would indicate that I consider *this nebulous matter as self-luminous, as well as capable of giving reflected light*:—to which opinion I am very strongly inclined. I had observations of other phenomena tending to confirm this opinion: but to notice them would lead me quite beyond my present limits, and into another subject.

§ 8. The opinion which I advanced at the meeting of the Scientific Association in Providence two years ago,—that this ring may be the source of our *aerolites*, seems to have much to support it: but there is not room to discuss it here.

Brooklyn, N. Y., Sept. 11th, 1857.

## Art. XXVIII.—*On a New Source of Electrical Excitation;* by Mrs. Elisha Foote.

(Read before the American Association at Montreal, Aug. 13th, 1857.)

I have ascertained that the compression or the expansion of atmospheric air produces an electrical excitation. So far as I am aware this has not been before observed, and it seems to me to have an important bearing in the explanation of several atmospheric and electrical phenomena.

The apparatus used was an ordinary air-pump of rather feeble power and adapted either to compress or exhaust the air. Its receiver was a glass tube about twenty-two inches in height and three in diameter, with its ends closed by brass caps cemented to it. At the bottom was a stop-cock and a screw by which it was attached to the air pump. To the top were soldered two copper wires, one hanging down within the tube, terminating in one or more points and extending to within about six inches of the bottom, the other extending from the upper side of the cap to an ordinary electrical condenser.

In experimenting after compressing or exhausting the air within the receiver, the wire reaching to the condenser was disconnected from it. The upper plate was lifted from its place by its glass handle and its electrical condition tested by a gold leaf electrometer. I have found it convenient first to compress the air and close the stop-cock, when the condenser would be found to be charged with positive electricity. Then after discharging all traces of it both from the condenser and the wire leading to it, the air was allowed to escape, and the condenser would become recharged to an equal extent.

My experiments with this apparatus have extended over about eight months, and I have found the action to bear a strong analogy to that of the electrical machine. In damp or warm weather little or no effect would be produced, whilst at other times, particularly in clear cold weather, the action would be so strong as to diverge the leaves of the electrometer to their utmost extent. In warm weather when no action would be produced, I have attained the result by cooling the air artificially. A sudden expansion or contraction always increases the effect.

The results with oxygen gas were similar, but I was not successful with either hydrogen or carbonic acid gases.

It is believed that the results which have been obtained on a small scale in my experiments may be traced in the great operations of nature. The fluctuations of our atmosphere produce compressions and expansions sufficient to cause great electrical disturbances. Particularly should this be observed in the dry cold regions of our atmosphere above the effects of moisture and

vapors; and it was established by the experiments of Becquerel as well as those of Gay Lussac and Biot that the electricity of the atmosphere increases in strength with the altitude.

A manifest relation, moreover, between the electricity of the atmosphere and the oscillations of the barometer has frequently been observed. Humboldt, treating upon the subject in his Cosmos, remarks among other things that the electricity of the atmosphere, whether considered in the lower or the upper strata of the clouds in its silent problematical diurnal course, or in the explosion of the lightning and thunder of the tempest, appears to stand in a manifold relation to the pressure of the atmosphere and its disturbances.

The tidal movements of our atmosphere produce regular systematic compressions twice in twenty-four hours. These occur with so much regularity within the tropics, as observed by Humboldt, that the time of day is indicated within fifteen or twenty minutes by the state of the barometer. And Saussure observed a diurnal change in the electricity of the atmosphere corresponding with the diurnal changes of the barometer. The electricity of the atmosphere, he observes, has therefore a daily period like the sea, increasing and decreasing twice in twenty-four hours. It, generally speaking, reaches its maximum intensity a few hours after sunrise and sunset, and descends again to its minimum before the rising and setting of that luminary.

Other phenomena, which it is believed may be traced to the same cause, will be the subject of another communication.

---

## Art. XXIX.—*On the Quantitative Assay of Chromium by Blowpipe Processes;* by Eugene W. Hilgard, Ph.D.—(Abstract.)

(Communicated at the Montreal meeting of the American Association, Aug., 1857.)

The quantitative determination of chromium has thus far been mostly confined to the laboratory. The processes employed were rather long, especially when many other elements occurred with the chromium, giving rise to a great variety of methods, requiring apparatus too voluminous to be carried in the field. No general method sufficiently simple and expeditious for practical purposes has been devised—methods such as we possess for most of the useful metals, and which the genius of Plattner has so admirably adapted to performance by the aid of the blowpipe. *Expeditiousness of execution* and *compendiousness of the utensils* required, are the characteristics of these processes of Plattner, and the main conditions of their practical usefulness; and it is to the exclusive employment of the dry way that these advantages are mainly owing. The metals being, after a

simple fusion, obtained in the shape of beads, does away with the tedious processes of filtration and evaporation; and if in a few cases the results thus obtained are not quite as accurate as those arrived at in the wet way, they are quite sufficiently so for all practical purposes. With metals difficultly fusible and reducible, which can not be brought into any available alloy (such as, besides others, iron and chromium), we are obliged partially at least to resort to the wet way. A mixed method of this kind has been proposed by Plattner for iron; and the one I now propose for chromium is of a similar kind. It is primarily intended for use in the field; also by the manufacturer to whom examinations of complex residues are frequently recurring; similarly it may serve to determine quickly and with considerable accuracy the value of the commercial preparations of chromium. In this I have not, however, invented any process essentially new. I have only attempted to adapt to the particular purpose in view, phenomena well known before, and there is undoubtedly room left for a good deal of improvement as it is. In describing the particular manipulations, I shall suppose the reader to be acquainted with the micro-laboratory of Plattner (his *blowpipe chest*), and his book on the same subject.*

The first step, as may be supposed, is the conversion of the chromium contained in the ore into chromic acid by fusion with alkalies and the simultaneous action of oxydizing agents, by which process chromium is at once separated from nearly all of the basic elements. In the qualitative test, this fusion is performed in the large platinum spoon, before the blowpipe flame. This process is always accompanied by mechanical loss from spirting of the flux, especially when *nitre* is used, without which, in most cases, the process is a slow and imperfect one. I found that a very slight admixture of phosphate of soda lessens the spirting very much; but I could find no means of preventing it altogether in an open vessel. I found it most convenient to use a platinum crucible of the same size and pattern as the clay ones ordinarily used; covered by a platinum torrefaction dish put on bottom downwards, and bent slightly out of shape, so as when set on to leave on one side a small orifice between itself and the rim of the crucible. The object of this orifice is to give exit to the gases, especially when, as sometimes happens, the flux inside rises so high as to reach the cover. But for this orifice (which must be kept very hot during the fusion) the cover would in such a case be lifted off by puffs, allowing the ejection of particles of the flux.

Of all fluxes hydrate of potash acts most powerfully on chromic iron ore; but in practice its use is inconvenient, partly

* The *spoon*, *lamp*, and other apparatus referred to beyond, are those of Plattner's *chest*.

on account of the excess of water the commercial reagent contains, and partly because of its powerful action on platinum, which would soon destroy any ordinary crucible. Carbonated alkalies are much more manageable; their effervescence with some substances is inconvenient at times; but there are cases in which they can not well be dispensed with. In the majority of cases, nitre alone answers perfectly, and it is decidedly the most convenient. The anhydrous potash formed in its decomposition does not act on the platinum perceptibly; it acts quite as powerfully as the carbonates; wherefore at present I generally confine myself to its use.

Supposing *chromic iron ore* to be under treatment; 100 milligrams of ore reduced to the finest possible division, are weighed off. The crucible is placed on the triangle of the lamp, and the ore being poured in first, three or four spoonfuls of nitre are added at once. The alcohol lamp is provided with its chimney, and so placed that by a simple movement of the support round its pivot, the orifice side of the crucible may be approached to or removed from the flame, which latter is so adjusted that the luminous cone is slightly truncated by the bottom of the crucible. The heat thus produced is quite sufficient in most cases; the rim of the crucible ought not be much heated, otherwise the flux will effloresce on the outside to such an extent as frequently to reach the triangle. If the latter is of iron, the experiment is lost; if of platinum, it may subsequently be washed off like the crucible itself. But with ordinary care, the accident is not likely to happen. In prolonged fusions, so much of the nitre is sometimes volatilized as to make it advisable to add some more. Care must be taken in lifting off the covering dish with the pincette, not to lose the drops of flux which usually adheres to its lower surface. If the ore has been sufficiently comminuted, its decomposition is usually complete in twenty-five to thirty minutes.

If the substance under treatment be *chrome ochre* or *chrome green* it is better to take only 50 to 75 milligrams for the assay; the nitre must not be added at once, but by half-spoonfuls, leaving the effervescence to subside each time before adding another, and allowing the fused mass to solidify on the surface. The heat must be very carefully regulated, taking as a guide the noise of decomposition. Unless this is attended to, the action is so violent as to render mechanical loss unavoidable. In these cases the completion of the oxydation is easily recognized; with the chromic iron ore, the only test is the absence of chrome in the washed residue. When the alkaline earths are present, either an alkaline carbonate must be used conjointly with the nitre, to insure the complete separation of the chromic acid; or else the substance may be treated like those containing lead, tin, bismuth, or cadmium.

Chromate of lead may be completely decomposed by fusion with nitre or the carbonates; but when the melted mass is treated with water, the reverse decomposition takes place, chromate of lead being again formed. Tin, bismuth, and probably cadmium behave similarly. This difficulty is best obviated by transforming those oxyds into silicates. The ore is first intimately mixed in the agate mortar with an excess (three to six heaped spoonfuls) of silica obtained in the wet way. A spoonful of nitre is then added and triturated with the mixture, whereby it is loosened from the mortar; it is then introduced into the crucible by single spoonfuls, as in the treatment of chrome green before described; after which the mortar is "rinsed" by triturating in it five or six successive half-spoonfuls of nitre. The flakes of silicate formed adhere to the sides of the crucible, appearing of a white or yellowish tint; if from incomplete mixture of the ingredients, any metallic chromate has remained undecomposed, it will appear of a dark red or orange on cooling. In this case no subsequent addition of silica will remedy the evil, and the experiment must be rejected. Most of these fusions are executed in from five to ten minutes.

The alkaline solution obtained by the treatment of the fused mass with water, may contain, besides the chromate, manganate, vanadate, tungstate, molybdate, titanate, silicate, antimoniate, arseniate, phosphate of potash, together with other non-metallic acids; those just mentioned being the most likely to interfere with the determination of the metal in view. It might be suggested to precipitate the chromic acid by $Hg_2O$, $NO_5$, when none of the above acids are present. Excellent as this method is when time can be allowed, its results fall seriously short of the truth when, as in the field, no delay is admissible. It would be better even to precipitate the chromic oxyd by ammonia, after reduction with alcohol. Neither of these methods is admissible when any of the acids mentioned are present.

It might be thought that a general method for the separation of the acids mentioned, would be found in the evaporation of the solution to dryness with HCl, and subsequent fusion with cyanid of potassium and an alkaline carbonate. But the oxyd of chromium thus obtained always contains potash, the amount of which is quite indefinite.

Passing over to the opposite of this plan, we find in the anhydrous potash chrome alum, $KO, SO_3 + Cr_2O_3, 3SO_3$, a compound insoluble in an *acid* solution in which most of the acids are soluble. It is well known that when a solution of chrome alum containing an excess of sulphuric acid is heated to 200° Centigrade, a light green powder of the above composition separates, which is insoluble and undecomposable by water or acids, and is but slowly resolved into its immediate constituents by boiling

potash-ley. It is however only an indefinite quotum of the chrome alum in solution which is thus precipitated. If the solution be still further heated, until oil of vitriol volatilizes, the whole of the chromium is precipitated in the form of a salt of the same composition as above, but which is slowly resolved into $KO, SO_3$ and $Cr_2O_3, 3SO_3$ (insoluble) by *hot* water alone, while it is not changed by cold water. When ignited, sulphuric acid, escapes and $KO, SO_3 + Cr_2O_3$ are left behind. It is upon the formation of this salt that I have based a general method of determination; finding that its formation is quite independent of the presence of any acid, and many basic substances, so long as an excess of $SO_3$ and potash are present at the same time.

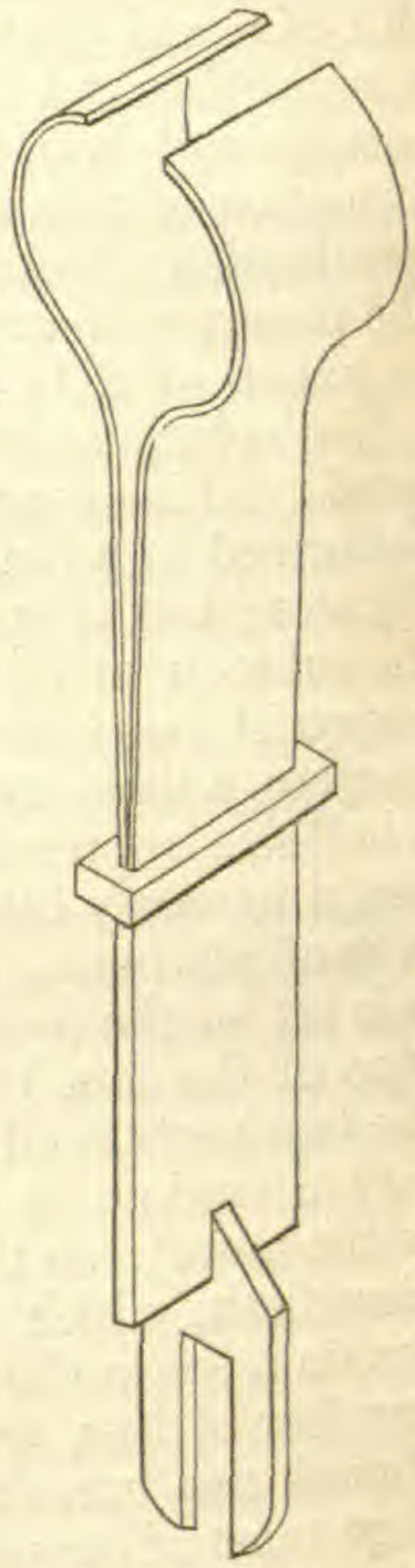
The solution containing the potash salts requires to be evaporated. This evaporation would be most safely and expeditiously performed in a long-necked glass flask, as with other voluminous filtrates; but it is difficult to find glass which will safely resist the subsequent bisulphate fusion. Even the porcelain dishes do not resist many of the latter. I have therefore contrived for the purpose a little evaporator of which fig. 1 is a half-size representation, and which is very useful in many other cases. The lower part, *a*, is of platinum, the upper, *b*, of thin glass; it is set on the lower vessel where the curvature of the rim begins. The seam between the two parts is effectually closed up by capillary attraction, as soon as any fluid is boiled in the vessel; so that the whole represents a close flask, which may be filled with fluid to within a few millimetres of the seam without any fear of loss, even if, in boiling, the froth should rise into the neck of the glass cover. Care must of course be taken not to heat the *rim* so as to cause boiling of the closing fluid.

1. (Half-size).

Silicic and manganic acids, when present in the solution, must be precipitated *before* filtering; the latter by a few drops of alcohol, and the former by a spoonful of nitrate of ammonia. In this case the solution must be boiled before filtration, to make the $SiO_3$ collect in flakes, otherwise there is difficulty in filtering. The crucible having cooled after the nitre fusion, is therefore transferred, together with its cover, to the evaporator, which is about one-third full of water. The solution may then be accelerated by heating, after which the precipitants just named are added and the whole boiled for half a minute, the vessel being covered with the watch-glass-shaped platinum cover used in the bisulphate fusion (see below); after this the fluid is transferred to one of the small beakers, vessel and cover being economically rinsed

and then set up for evaporation. Filtration and evaporation are to be carried on simultaneously. The platinum vessel is set on the grate of the lamp; the glass cover is clamped into the holder (fig. 2, full size), which in its turn is clamped into the same arm which carries the filtering support; the two parts are then joined and adjusted to the proper height.

2.



A two-inch filter is about the proper size in this case. Filters as small as these may be made so as to form an angle 5–8° larger than that of the funnel, so that while closely adjusted at the upper edge, their lower part hangs free within. The weight of fluid is insufficient to break down the paper, while filtration is essentially accelerated. So soon as the principal solution has passed through, it is poured into the evaporator from above (without soiling the neck) and evaporation begun. Previously, however, oil of vitriol is added until the solution becomes dark and free from chromic acid; then five to eight drops more, and finally three to eight spoonfuls of bisulphate of potash, the quantity varying *inversely* as the amount of nitre previously used. An excess does no harm. From time to time the filtrate is transferred to the evaporator, except the last one and a half or two fluiddrachms, which are reserved. The evaporation usually goes ahead of the filtration, and when finally the fluid in the evaporator is reduced so low as to evolve white fumes of nitric acid, the lamp is removed, the arm carrying the glass cover slightly raised, then moved sideways, and the glass unclamped. The latter is then rinsed into the platinum vessel with the reserved part of the filtrate, and finally and very economically, with the washing bottle. The whole of the rinsings ought not to fill more than one-third of the vessel, which is then covered with a watch-glass-shaped platinum cover, slightly smaller than the circumference of the rim, and not fitting too closely all around. Thus the fluid may be kept briskly boiling without loss; in a short time a frothing noise is heard, and shortly after fumes of oil of vitriol appear. At this period the clear green liquid suddenly changes color, and deposits a peach-blossom-colored powder, which on cooling turns light green. The heating is continued until *dense* fumes cease to issue; the fire being then removed, and the cover carefully laid aside, *upside*

*down*, the vessel is taken up with the pincers and the fused bisulphate made to spread itself on the sides as much as possible. Since no heat must be applied in the solution of the mass, it would be extremely tedious to wait for the solution of the dry bisulphate thus remaining. Five to six drops of oil of vitriol are therefore added, and the mass reheated with these; on cooling subsequently, it remains sufficiently soft to dissolve in water almost instantaneously. The cover is first rinsed into a small beaker, which may be filled to about one-third; the whole of this fluid is afterwards poured into the platinum vessel, and the solution promoted by stirring, so as to prevent any parts of the mass getting sensibly heated. When many foreign substances are present, it is best to add some more acid subsequently.

The precipitate cannot be washed with pure water. Salts, especially AmCl, prevent its diffusion in water, yet not sufficiently to make it wash expeditiously. It is necessary to involve it in some other precipitate settling quickly, not interfering with the separations, and volatile in the subsequent ignition. Such a one I found in the chlorosulphid of mercury. Half a spoonful of corrosive sublimate is added to the bisulphate solution, and while stirring violently, dilute sulphid of ammonium is added until, when the precipitate turns of a dark olive tint, the liquid above the flocculi is perceived to be clear. It may then at once be filtered; during the washing a little HgCl is thrown on the filter. Two and a half inch filters are best; the amount of ashes they give must of course be accurately known.

The filter is dried between blotting sheets, formed into a square package and incinerated in the platinum torrefaction dish, in a roasting furnace, after having driven off most of the mercury over the spirit lamp. The incineration is somewhat difficult; after it is complete, the loose mass is transferred to the platinum crucible previously counterpoised on the balance together with a small wire tripod (fig. 3). The crucible being covered with the torrefaction dish, is placed on the furnace, which is closed and provided with charcoal cover. A strong and steady heat is then maintained for four to six minutes, making the flame dart out at the chimney-hole. The mass will then appear dark green all over; if the heat has been strong, some chromate may have formed, which would vitiate the result. The whole is therefore moistened with a drop of strong sulphid of ammonium, then carefully dried over the lamp and gently re-ignited. Deducting the filter ashes from the weight of the residue, the result is calculated, 100 of residue corresponding to 47·3 of chromic oxyd.

3.

With proper care in the execution, the results obtained by this method are very satisfactory; generally rather a little too high, but rarely more than 0·1 milligram from the truth, and remarkably constant. The time required is generally about one and a half to two hours.

Of the acids above mentioned, I have not had opportunity of experimenting on the *titanic* and *vanadic;* but it is not likely that they would cause any difficulty in the separation. *Tungstic* acid remains with the green precipitate, and renders it flocculent, so as to make the use of the mercurial salt superfluous. After washing the filter a few times, six to eight drops of strong ammonia are poured on the filter, which is subsequently washed with an ammoniacal solution of sal-ammoniac. The separation is thus effected without difficulty. When *antimony* is present, the solution after the nitre fusion must be effected *without boiling*, and the residue washed with solution of nitre; if silica has to be precipitated, it must be made to collect in flakes by shaking in a test tube. After the bisulphate fusion, a spoonful or two of *tartaric acid* are thrown into the beaker before rinsing the cover. In the presence of copper, either silica must be added in the nitre fusion, or more simply, some caustic potash is added to the boiling solution, before precipitating the silica, if any. The chromate of copper then contracts into black scales of pure oxyd. The presence of a large amount of *magnesia* renders it advisable to add silica in the nitre fusion, lest too much of that earth should be carried over into the bisulphate solution by the ammoniacal salt. A small quantity does not vitiate the result. When the *halogens* are present, it is necessary to expel them before the nitre fusion. This is done by a preliminary fusion with a small quantity of bisulphate of potash, when chromic *oxyd* alone is present; if there is chromic *acid*, it must be previously reduced by heating with KCy or KO, $OxO_3$, otherwise the chromium will be partially volatilized. If simultaneously reducible metals are present which would endanger the platinum crucible, the fusion must be effected in a porcelain one. *Tantalic* and *niobic* acids would, like the tungstic, remain with the precipitate. As they are not likely to interfere often, I have not devised any method for their separation, which might require another filtration. The rest of the elements are separated without difficulty, in the ordinary course of the assay.

## Art. XXX.—*Remarks on Fluorine: Action of Acids on Glass;* by Jerome Nicklès.

The usual process for detecting the fluorine in a compound not siliceous, is to set the fluorine free as fluohydric acid commonly from a vessel of lead or platinum and subject to its action a plate of glass. The process has been long in use, and is of value when there is much fluorine present. When the substance under examination contains only a trace of fluorine, and no corrosion of the glass is visible to the naked eye, it has been known that the effects of the reaction could be rendered visible by moistening the surface slightly with the vapor of water or with the breath; the parts acted on become distinct, and remain so as long as the slight film of vapor continues. This trial has till now been relied on with full confidence. On its indications, the presence of fluorine in many rocks and mineral substances has been admitted; and what is most to be wondered at is, that this element has not been found everywhere, since the reagents used in developing it themselves contain it.*

In fact, sulphuric acid, purified by whatever known process, may still contain some fluorine, which it has received through the nitrate of soda employed for oxydizing the sulphurous acid.

Again, another cause for the corrosion of the glass is found in the action of the acids themselves when in the state of a vapor, which, in cases like those under consideration, may sometimes equal that of fluohydric acid itself. The following simple experiment, which may be made in a quarter of an hour, proves this point. Cover a plate of glass, as usual, with wax,

* Since the publication of the above note in the Comptes Rendus for March, 1857, a reclamation of priority has appeared, which justifies what I have said. This reclamation is from Mr. Wilson, Professor of Chemistry at Edinburg, and it was presented to the Royal Society of that city. He there establishes that ten years since he found fluorine not only in the blood and all the liquids of the organism, but also in plants, various waters and minerals, that is, probably, wherever he sought for it. The same thing happened to me when I began my researches, and the difficulty was to find a substance that did not contain it. I found it in the crucibles which I used, and the capsules in which I evaporated the waters; but then I had not found it in the sulphuric acid used in my investigations. This I afterwards succeeded in doing, (see a paper beyond,) and this put a new phase on the problem, and I was led even to doubt its presence in bones. Before, I could obtain fluorine from the carapax of the lobster; but now, using sulphuric acid pure from fluorine, I find none in even 200 grams of the carapax. It is plain that if a fluoriferous acid be used, the presence of fluorine will be shown in the results. Moreover the vapors of sulphuric acid can act feebly like a feeble amount of fluohydric acid and produce an impression on glass appreciable after being breathed upon. As Prof. Wilson made his experiments with sulphuric acid, and with large quantities of it, he should have had traces of its presence. He states that he found fluorine in the waters of the Atlantic. I do not know on what scale he operated. But while at first I could find it in ten litres of the water, afterwards, on subjecting rock crystal to the vapors instead of glass, and using pure sulphuric acid, I found none with 300 litres.

and make a tracing of any regular figures: then fill a platinum crucible half full of sulphuric acid, and turn in some water sufficient to raise the temperature considerably, and cover the crucible with the glass, keeping the glass cool above by water. Add more water from time to time to the acid, as the temperature declines, until there is no further increase. At this point, the experiment is done; the lines of the tracing on the glass will be corroded distinctly to the naked eye. From such a result the presence of a notable proportion of fluorine might be inferred. But it is easy to prove the contrary: for if the acid be neutralized by an alkaline base so as to make a sulphate, and this salt be subjected to the action of an acid capable of displacing the fluohydric acid, the tracing is no more visible than it would be if the acid employed had acted itself alone, that is, it is visible only after moistening with the breath.

In the state of vapor, all acids will act with more or less energy on glass, and cause an etching,—a fact that should not surprise us when we consider how easily water will attack glass in powder. These effects take place, even when silica is present, which again proves that they may contain no fluorine. To obtain the best results, it is well to place the crucible in a sand-bath, and to keep the glass quite cool.

Two causes of error thus enter into the researches on fluorine, causes which the processes hitherto employed cannot avoid or set aside. The process I use is simple and serves to correct both assertions and errors. It consists simply in substituting rock crystal for the glass plate, the former resisting all action but that of fluohydric acid, and its sensitiveness to the latter being so great as to evince the presence of 0·000066 milligram of fluorine.

Among the errors to be corrected are those of my own, with reference to the presence of fluorine in bile, saliva, and gelatine. In ten grams of saliva I formerly obtained a decided tracing on glass. But with *pure* acid I now find none with sixty grams, or even ninety. Twenty litres of blood were necessary to obtain an appreciable effect from the fluorine.

But if there is fluorine in the blood, it should be found in alimentary substances. Still, I have not detected it in 200 litres of the waters of the Rhine, or of the Ill (Bas-Rhin), or in those of the Moselle, La Meurthe, La Meuse, La Seine; nor in 200 grams of the shells of oysters or of wood ashes: these substances still contain small quantities, and it is to be detected only by using much larger proportions. The most simple and economical means of discovering the presence of fluorine in waters is by the examination of the incrustations of boilers. These incrustations represent the product of the evaporation of a very large quantity of water, and they not only, in general, afford fluorine, but many other substances in small proportions.

With mineral waters it is often sufficient to employ a few litres only to find fluorine. Thus the mineral water of Plombières contains more than that of Vichy, and less than that of Selters or Antogast. It has been detected with four litres of the water of Plombières, eight of that of Vichy; while it is not distinguishable in eight litres of that of Niederbrunn, nor in sixteen of the water of Soultzmatt; and again it may be detected in one litre of the water of Châtenois. Thus while fluorine is generally present in mineral waters, the proportions vary largely. Besides, we may conclude that mineral waters rich in chlorids are not, as has been believed, a result of the infiltration of the waters of the sea.

---

## Art. XXXI.—*On Fluoriferous Sulphuric Acid and its purification;* by Jerome Nicklès.

It is now forty years since chemists were surprised by an announcement by Mullen, that when peroxyd of manganese or minium, free from chlorine, is treated with dilute sulphuric acid, a certain quantity of chlorine is evolved. It is useless to recall the hypotheses provoked by this curious reaction, appearing at a time when the nature of chlorine was little understood. At present, the mystery has passed away, and it is well known, that the chlorine was derived from a small quantity of hydrochloric acid existing as an impurity in the sulphuric acid of commerce.

But the fact respecting chlorohydric acid is now found to be true also of fluohydric acid; and it is evident from the preceding paper that already much confusion and error have arisen from this impurity in sulphuric acid derived from the nitrate of soda employed in its manufacture.

The practicability of purifying this acid I have proved on samples taken from various sources.

In my first trial I endeavored, in view of the volatility of this hydracid and its affinity for water, to drive it off by the heat of ebullition after diluting the acid with as much water. But it was a failure; the hydrofluoric acid was retained in consequence of the well known powerful action of mass, a large quantity of one substance (the sulphuric acid) controlling the other which was in so small proportions.

After various attempts, among which gelatinous silica was tried, I came to the following very simple process. In a porcelain capsule, or better still, in the bulb of a retort, the neck of which has been removed, a certain quantity of the acid to be purified was introduced, and diluted with twice its volume of distilled water; it was then placed in a sand-bath and heated

till the liquid had a slight movement, without actually boiling; this operation was continued for a greater or less time, usually thirty hours sufficing to obtain the sulphuric free from fluorine.

To test its purity the following method may be adopted. Put about thirty grams of the acid in a platinum crucible large enough to contain twice this quantity; add ten grams of distilled water, and immediately cover it with a plate of rock crystal which had been prepared with wax and traced over with regular geometrical figures,—such figures being more easily distinguished than others from any accidental striæ or markings. The rock-crystal should be kept cool with water, which for this purpose should be often renewed. The vapor of the water produced by the heat at the first contact of the water and acid, naturally condenses at first upon the cooled rock crystal. It is indispensable that this condition should be fulfilled; for the slight dew covering the bed of wax intercepts the fluohydric acid, which, as is well known, is very soluble in water, and acts only moderately on glass when it is free from humidity.

When the acid is so far diluted as not to heat up by the addition of a new quantity of water, it is necessary to have recourse to the lamp or sand-bath.

The temperature should be such that the hand cannot bear direct contact with the crucible. After two hours, the operation is completed. Then withdraw the crystal plate and remove the wax, wiping with care and cooling it. If there is no tracing apparent to the naked eye, and none while the film of vapor from the breath covers it, it gives evidence of purity from fluorine.

When, as in the old process, we operate with a plate of glass, and act upon carbonate of lime, such as calcined shells, shell of lobsters, &c., it takes but little time to obtain the corrosion; an effect which has, in fact, been already attributed to the presence of fluorine. This is what was done by M. Jenzsch, with the spars and aragonites,* and also by Mr. Wilson. These effects are easily explained; for a new affinity enters into play between the carbonates, an affinity which modifies that between the sulphuric and fluohydric acids, and the latter acid, as a consequence, cannot fail to be disengaged.

We may then, in the preceding experiment, use one of these agents, and the better to insure success, it should be moistened with a little distilled water. The experiment may then be finished in half an hour, especially if aided by heat. This process, based on the partial neutralization of the sulphuric acid under examination, is more sensitive and, especially, more expeditious than the preceding.

* Poggendorff's Annalen, 1855.

## Art. XXXII.—*On Parthenogenesis.*

The subject of parthenogenesis in animals, and especially with reference to the Aphides or common plant-lice, was discussed in this Journal, early in 1854, by Dr. W. I. Burnett. Dr. Burnett brought to the question the results of his own minute researches, carried forward with the exactness and skill which are known to have characterized all his microscopic investigations. Since then, the subject has been growing in interest, and under its new name, parthenogenesis, it is taking more the aspect of a recognized principle in the Sciences of Life. The word, as its derivation implies, signifies the production of young by the female sex alone; and in the Aphides, generation follows generation, for a dozen or more, without renewed intercourse with the other sex.

Dr. Burnett appreciated the fact, that there were two modes of generation well known in plants and animals,—one by true eggs, the other by buds without eggs. The plant kingdom is known to be full of both processes. The bud from a branch, developing regularly its leaves, and capable as it often is of propagation when separated as well as when united to the original stem, is one variety of propagation by buds. The bud originating as a bulb at the axils of the leaves and branches, which drops off, and on finding soil, produces a new plant, is another variety of growth by buds. As each plant from such a bulb or bulbel will produce its crop of bulbels, propagation may be continued on, apparently indefinitely, without the necessary intervention of true flowers.

The Animal Kingdom in its inferior departments of the Radiates and Molluscs, exemplifies the same method of propagation. The young polyp may grow from the side of the old, and be persistent, like ordinary buds of plants, but become an independent individual if cut off; or in other cases, it may drop off on reaching towards maturity and thus acquire independence and so become the parent of a new zoophyte.

Thus far, the two kingdoms have been long known to be alike in reproduction. The bulbels of the plant are not like true seed in structure, neither are the bulbels of the Campanularidæ. There is not the germinal vesicle with its germinative spot. The development is simply gemmation. The analogies between plants and animals, it may be stated, go still farther: for as plants produce leaf buds, and then flower buds in which sexual organs and seed are developed, so some Medusæ (Tubularidæ) bud out polyps, to make the branching stems, and afterwards bud out Medusæ to develop sexual organs and ova: these Medusæ (as occasionally happens with the flowers of plants) separating and becoming free from the stalk that produced them. Moreover it

is now understood that the so-called alternation of generation is nothing more than the successive states exemplified in plants, of the embryo, incipient leaf bud, opened leaf bud, flower bud and flower, all of which are often widely diverse in forms.

It was in view of such facts as these that Dr. Burnett undertook to determine the nature of the process of continued non-sexual propagation in the Aphides; and his conclusion was, that the egg-like bodies, developed in clusters within the producing Aphis, were of the nature of buds, and not true ova, agreeing in this with Dr. Carpenter; and that the whole was analogous to the budding process. "The germs," he says, "have none of the structural characteristics of eggs, such as a vitellus, a germinative vesicle and dot; on the other hand, they are at first, simple collections, in oval masses, of nucleated cells." He also refers to the same kind of origin, the so-called hibernating eggs of *Daphnia* among Crustacea, *Lacinularia* among the Rotatoria, and *Hydatina* and *Notommata* among the Infusoria, in which, he observes, no germinative vesicle or dot has been seen, and no connection with the ovary discovered.

Parthenogenesis in the Aphides, according to this view, is reproduction by buds or gemmiparous reproduction, as distinct from sexual reproduction. It is like leaf-budding, the flower-budding (or sexual developments) taking place at longer intervals.

The later investigations of some zoologists have been tending to the conclusion that even true eggs, or bodies having the structure of eggs in every essential point, may be produced in some cases by females, and develop into perfect individuals without the intervention of the male, and without any proper hermaphroditism in the parent. The most important work that has appeared on this subject is one on "Parthenogenesis in Moths and Bees," by C. T. E. von Siebold of Munich, which has been translated in England by W. S. Dallas. The author describes the raising of brood after brood of young from some moths, without the recurrence of a single male; and in a *Psyche*, the pupa-case is filled with eggs before it is left; and in a *Selonobia*, the animal immediately after leaving the case, stuffs it full of eggs. The main point in his work, and one of more questionable character, relates to bees. He adopts the theory of a Silesian clergyman named Dzierzon, and after farther elaborating it, sustains the view that "the queen-bee, which like all other female insects, receives the seminal fluid of the male in a peculiar receptacle, there to be retained until it comes in contact with the egg during its passage through the oviduct, possesses the power of permitting or preventing this contact, so that the eggs may be deposited in the cells, either fecundated or unfecundated, at the pleasure of the mother; and farther, that from the fecundated eggs, female larves are produced which become developed either

into queens or workers, whilst the unfecundated eggs furnish the larves of the drones or males." The following are some of the points of evidence adduced in support of this remarkable theory, as given in a notice of the work in the Annals and Magazine of Natural History for July last.

"It is now generally admitted, even by bee-keepers, that the queen only copulates once, and that the supply of seminal fluid received at this time, and stored up in the seminal receptacle, serves for the fecundation of the immense number of eggs which she deposits during the period of her fertility, extending over several years. Sometimes, however, the stock of spermatozoids appears to be exhausted before the life of the queen comes to a close, and when this is the case she lays nothing but drone-eggs, introducing confusion into the wonderfully harmonious arrangements of the hive. This was found to be the case also with a queen which had been exposed to severe cold, with the view of destroying the vitality of the spermatozoids; of three queens thus treated, only one survived, and this afterwards laid nothing but drone-eggs. Another queen, whose abdomen had been injured so as *probably* to displace the seminal receptacle, also produced drone-eggs exclusively. Added to this, certain workers, which as is well known, are merely abortive females, destitute of copulative organs and of the seminal receptacle, and therefore incapable of fecundation, are found to possess imperfectly developed ovaries, which produce a very small number of eggs, and these, when deposited in the cells, are said always to produce drones. For most of these facts, von Siebold appears to have been indebted to the apiarians Dzierzon and von Berlepsch; but perhaps the most remarkable observations are those made by himself, in the microscopic examination of a considerable number of newly-deposited eggs. In the majority of the eggs deposited in worker-cells examined by him, he found spermatozoids; sometimes as many as four. In some instances these singular filaments still retained the power of motion. On examining twenty-seven drone-eggs laid by the same queen which had furnished a portion of the female eggs, von Siebold did not discover a single spermatozoid.

Such is the outline of the results at which the distinguished author has arrived; and although many will perhaps be disinclined to give an unhesitating adhesion to his views, there can be no doubt that his work is one of the most important that has appeared for a long time, one well worthy of being carefully studied by all physiologists, and one that must in the end greatly advance the cause of science, if only by calling the attention of observers to this singular and much neglected subject."

J. Lubbock, Esq., of England, has recently examined the so-called hibernating eggs of the Daphnia, and published his results in a valuable paper in the Philosophical Transactions, for 1857. These eggs, which he styles *agamic* eggs, are more abundant than the "ephippial" eggs, usually regarded as the eggs of the ordinary kind, and unlike the latter, they possess the power of development without impregnation. They are formed in the ovaries like true eggs, either in front of or behind the ephippial

mass; and moreover after close microscopic investigation Mr. Lubbock states that their formation appeared to commence from a cell or germinal vesicle like the ephippial egg, and differed little apparently in the process of enlargement excepting in the addition of one or more oil-globules. As the development proceeded, a very delicate membrane (vitelline membrane) forms about the egg. In about four days after a preceding brood had been produced, another brood was ready to enter the receptacle, the preceding having by this time developed sufficiently to swim about freely in the water. Mr. Lubbock remarks concerning the corresponding facts in the Aphides:

"If we except the non-essential difference, that in *Daphnia* the developing eggs do not alter their place in the ovary, the whole process as now detailed, is so similar to that which is described by Leydig in the Aphides, as to confirm in a remarkable manner his observations, and on the other hand, of course, to throw more doubt on the entirely different accounts of J. V. Carus and Dr. Burnett. I must, however, confess, that like the two last-mentioned observers, I have been quite unable to detect any germinal vesicle in the eggs of the viviparous Aphides; it is, however, very difficult to find even in those eggs which are destined to be impregnated in the ordinary manner, or indeed in any insect eggs, while, on the contrary, I have found it to be very large in all the eggs of Crustacea which have come under my notice."

Mr. Lubbock gives a brief notice of various papers bearing on the subject of Parthenogenesis, which we cite.

"The Crustacea are so seldom bred and watched in captivity, that although the Daphniadæ is the only family in the class which is as yet known to reproduce by parthenogenesis, yet the instances may hereafter prove to be much more frequent, as the fact that no males have yet been found of *Polyphemus oculus*, *Limnadia gigas* or *Apus* would seem to suggest.

"Similar phenomena have been recorded by Dumeril,* and more recently by Newman.†

"In the Insects, excepting the celebrated case of the Aphides and the genera *Cynips* and *Apophyllus*, as stated by Hartig,‡ whose assertions have been confirmed by the appearance of *Cynips lignicola* in great numbers in the southwest of England within the last year or two, where in several thousand specimens not a male occurred;—with these exceptions, I say, the phenomenon of parthenogenesis has as yet only been met with in the Lepidoptera, probably because this is the order most frequently bred by collectors.

"Pallas has observed this phenomenon in *Euprepia casta;* Bernoulli in *Gastrophaga potatoria* and *Episema cæruleocephala;* Basler in *G. quercifolia;* Suckow in *G. pini;* Treviranus in *Sphinx ligustri*, and

* Académie des Sciences, 28th Sept. 1856.

† An Essay on the employment of Physiological Characters in the Classification of Animals.

‡ Germar's Zeitschrift, vol. ii, p. 178.

Nordmann in *Smerinthus populi.* These instances are mentioned in Burmeister's Manual, p. 312; and Siebold* has attempted to explain them away, but in the present state of our knowledge the assertions are more probable than the explanation.

"Moreover, Siebold himself has observed parthenogenesis in *Solenobia lichenella* and *S. clathrella*,† in *Psyche helix* and in *Apis*.‡

"Lacordaire§ mentions the same fact as having occurred in *Liparis dispar* for three successive generations.

"Mr. J. P. Brown‖ has observed parthenogenesis in *Sphinx populi* and in *Arctia caja*, and states that M. Wagner has observed the same in *S. ocellata.*

"M. H. Lehocq¶ has met with a similar instance in *Arctia caja;* Dr. Kipp in *Sphinx populi*,** quoted by Siebold; Mr. Johnston in *Smerinthus ocellatus*;†† Mr. Curtis in *Bombyx polyphemus*;‡‡ and in *Bombyx mori* various naturalists have convinced themselves of the same facts.

"Mr. Westwood has favored me with the following extract from his unpublished notes:—'Mr. Davis (the publisher of the Entomological Magazine, and himself a good entomologist) informs me of a singular circumstance connected with the Egger moth, which has been observed by Mr. Tardy the Irish entomologist, after whom *Mesites Tardii* has been named, this gentleman having reared three generations of this moth from a single impregnation.'

"The Rev. P. H. Newnham of Guildford, the Rev. Hugh A. Stowell and Mr. E. W. Robinson have kindly informed me by letter that they have observed the same fact respectively in *Smerinthus populi*, *Arctia villica*, and *Arctia caja.*

"In *Psyche helix* and *Solenobia* parthenogenesis appears to be the rule, while in the other Lepidoptera it occurs as an exception; taking then these nineteen exceptional cases, it will be observed that they have all occurred in the hawkmoths or moths, and not one in the butterflies; four in *Smerinthus populi* and two in *S. ocellatus*, and three in *Arctia caja;* that, taking the genera, five are in *Smerinthus*, four in *Arctia* and *Gastrophaga*, and two in *Bombyx.* No doubt the silkworm moth (*B. mori*) has been so much and so carefully observed, that if parthenogenesis did occur even rarely in that species, it would certainly have been noticed by many observers; but I can suggest no explanation of the very unequal distribution of the other cases, except that agamogenesis does occur more frequently in some genera and species than in others, and *à fortiori*, that it takes place in some.

But if Professor Siebold and M. Dzierzon are correct, the Hive-Bee (*Apis mellifica*) presents us with the most wonderful instance of parthenogenesis as yet known among the Articulata, since in this instance the males always arise from unimpregnated eggs; and those eggs, which, if

* Wahre Parthenogenesis bei Schmetterlinge, &c.

† Bemerk. über Psychiden: Jahresbericht der Schlesischen Gesellschaft, &c., 1850; translated also in the Transactions of the Entomological Society of London, N. S. vol. vi.

‡ Wahre Parthenogenesis, &c.

‖ Mag. of Nat. Hist. viii, p. 557.

** Bienenzeitung, 1853, p. 1752.

‡‡ Ann. des Sc. Nat. 1851, p. 297.

§ Introd. to Ent., vol. ii, p. 383.

¶ Comptes Rendus, Dec. 8, 1856.

†† Zoologist, 1848, p. 2269.

impregnated, would have produced females, will, if no spermatozoa are present, give birth to males.*

"Several naturalists have convinced themselves that some plants have also the power of producing agamic seeds, and Gærtner has given an abridged account of the experiments on the subject.

"The plants in which the most complete experiments have been undertaken, and in which agamic seeds are supposed to have been obtained, are as follows:—

*Zea mays*, by R. J. Camerer, and again by Henschel; *Cannabis sativa*, by Spallanzani, Henschel, Giron de Buzareingues, Bernardi; *Spinacia oleracea*, by Spallanzani, Henschel, Giron de Buzareingues; *Cucurbita melopepo*, Spallanzani; *Cucurbita Citrullus*, Spallanzani; *Coyx Lacryma*, Henschel; *Lychnis dioica*, Henschel, Giron de Buzareingues; *Mercurialis annua*, Ramisch.

"Gærtner, however, is inclined to doubt the truth of the results obtained, and to ascribe the supposed agamic fertility either to pollen brought from a distance in the air, to the unnoticed presence of male flowers, or to 'crypto-hermaphroditism.' Mr. Smith, Curator of the Royal Kew Gardens, mentions a case of seeds which germinated without any apparent action of pollen as occurring in *Cælebogyne ilicifolia*, a native of Moreton Bay, and belonging to the Euphorbiaceæ, which was introduced into this country by Mr. Cunningham, who sent three plants to the Kew Gardens in 1829.

"These plants produced female flowers from which perfect seeds have been obtained for several successive years, although Mr. Smith could never detect 'anything like male flowers or pollen-bearing organs:' the ovarium and the seeds presented 'the usual structure of Euphorbiaceæ, such as it occurs in *Croton*, *Phyllanthus*, *Cluytia*, &c.'†

"Still more recently,‡ M. Henri Lehocq has observed the same phenomenon. He says, 'Mes expériences ont été faites sur le chauvre, l'épinard, le *Mercurialis annua*, le *Trinia vulgaris*, le *Lychnis sylvestris*, et sur une Cucurbitacée dont j'ignorais le nom spécifique. Je n'ai pas besoin de rappeler que j'avais pris toutes les précautions possibles pour isoler mes plantes, et cependant, à l'exception du Cucurbitacée et du *Lychnis*, toutes les autres me donnerent des graines fertiles.'§

"Dr. Carpenter,‖ and after him many authors, as for instance Dr. Burnett,¶ Carus,** and M. de Quatrefages, have sustained with ability the theory that the specimens which produce the so-called internal buds or gemmæ are not females, but entirely without sex. Thus, M. de Qautrefages†† says, 'Toutes les générations intermédiairies développées entre les termes extrêmes de ce cycle sont agames, c'est à dire, manquent de véritables organes reproducteurs, et se multiplient exclusivement par bouture et par bourgeon interne ou externe.'

"These and similar assertions, however true with reference to the Zoophytes, require great modifications with regard to the Articulata.

* Wahre Parthenogenesis, &c., *passim*.
† See Transactions of the Linnean Society, vol. xviii, p. 509.
‡ Comptes Rendus de l'Académie des Sciences, 8 Dec. 1856.
§ See also Journal of Microscopical Science, July, 1857, p. 228.
‖ *L. c.* p. 443. ¶ *L. c.* p. 96. ** *L. c.* †† *L. c.* p. 116.

"Prof. Siebold, who in his 'Bemerkungen über Psychiden,' in the 'Jahresbericht der Schlesischen Gesellschaft,' &c., 1850, p. 85, appears to have taken for granted that the self-fertile individuals of *Talæporia* (*Solenobia*) are, 'in ihrer organisation von weiblichen Thieren ganz verschiedene geschlechtslose Individuen' (in their organization from the female animals, entirely different sexless individuals), in his latest and very interesting essay, 'Wahre Parthenogenesis bei Schmetterlingen und Bienen,' admits that the self-fertile individuals in these insects are true females.

"This is also not the less evident in *Daphniæ*; for in them not only may the same specimen produce first agamic eggs, then ephippial, then again agamic, and then again ephippial eggs, so that it would have to be considered first sexless, then female, then sexless then female again, but actually, and that usually, the embryonic forms of both eggs are present at the same time."

"Throughout this paper I have applied the name of *eggs* to the ordinary reproductive bodies of the *Daphniæ*, although aware that it is customary to call all egg-like bodies which are fertile without immediate impregnation 'internal buds' or 'gemmæ,' and to consider them as essentially different from true eggs. Dr. Carpenter* and Dr. Burnett† have adopted this theory, and M. de Quatrefages also‡ says, 'Seulement chez les dernières [winged female Aphides, in opposition to the so-called sexless specimens] on trouve de véritables œufs, pourvus de toutes leurs parties caractéristiques; chez les premières de petites masses granuleuses, où l'on ne distingue jamais ni vitellus, ni vésicule germinative, ni tâche de Wagner.'

In this statement he probably relies on the descriptions of J. V. Carus and Dr. Burnett, but Leydig has already shown that there is good reason for supposing them to be in error; at any rate it is by no means applicable to the *Daphniæ*. In these we find in the ovary a number of ovarian masses containing small cells. One of these latter swells, dark granules collect around it, and it becomes a germinal vesicle. This is the foundation of an ephippial egg. Just in front, another cell swells a little, becomes surrounded in a similar manner by dark granules, and also by oil-globules, and this process continuing, forms the ordinary egg. I say *egg*: for how can we deny this term to a round body developed in the ovary of a female, and around a germinal vesicle?

"Truly has M. de Quatrefages observed,§ 'Ainsi l'on passe de la simple croissance d'un mammifère, au bourgeonnement le mieux caractérisé par des nuances insensibles: et tout nous ramène à cette importante conclusion, que le bourgeonnement, et par conséquent la réproduction agame, ne sont au fond qu'un phénomène d'accroissement.' But why stop the series here? Dr. Burnett says, indeed,‖ that 'the structure and conditions of all true ova are the same, and there is no passage between them and buds;' but this assertion is disproved by Leydig's observations on the Aphides,¶ and those now related in the *Daphniæ*. Prof. Owen, on the contrary, has maintained that buds and eggs are not bodies essentially different in their nature, but that we may expect to find every gradation

* See Dr. Carpenter "On the Microscope and its Revelations," p. 279.
† *Loc. cit.* ‡ *Loc. cit.* p. 121. § *Loc. cit.* p. 129.
‖ *Loc. cit.* p. 88. ¶ *Loc. cit.*

between them. It will probably ere long be convenient to apply some distinguishing name to those egg-like ovarium products which do not require impregnation as a necessary antecedent to development, but for the present, at any rate in the *Daphniæ*, we must call them eggs, which they more nearly resemble than ordinary gemmæ.

"Prof. Huxley might be supposed to agree with the naturalists as to the essential difference between eggs and buds above-mentioned, since he has proposed, developing the idea of which we owe the germ to Dr. Carpenter, to extend the use of the word 'individual' to the whole product of one impregnation, and to designate as 'zooids' the independent forms of the individual.* Prof. Huxley, however, proposes this system of nomenclature merely as convenient, and not as expressing any fundamental, structural, or potential difference between eggs and buds."

The investigations are still going on, and the subject is receiving thorough study. A paper on the topic was presented to the recent meeting of the American Association by Berthold Seemann which has not yet been published. We quote a single paragraph respecting Parthenogenesis in Plants from a paper by Dr. L. Radlkofer of Munich, published in the Annals and Magazine of Natural History, for September (xx, 204), relating particularly to the *Cœlebogyne ilicifolia*, which plant was first observed to be an example of parthenogenesis by J. Smith. (Linn. Trans., xviii, 509.)

"In the first rank here must be mentioned the observations on *Cœlebogyne ilicifolia*, a dicœcious Euphorbiaceous plant, native of Australia, female specimens of which were long since introduced into England, and were widely distributed from there, before the male plant had been detected by travellers in its native country. No living specimens of the male plant have yet reached Europe; only a dried shoot with male flowers exists in the Herbarium at Kew. A glance at this suffices to show, from the composition of the inflorescence of the plants, the impossibility of the occurrence of a hermaphrodite flower in *Cœlebogyne*, and to show, further, that if the exceptional case which has been observed in other plants, of a production of male flowers on female specimens of dicœcious plants, occurred in *Cœlebogyne* also, it could not be overlooked. Finally, all botanists who have had an opportunity of examining the female plants of *Cœlebogyne*, and among these are numerous authorities, agree in declaring that no male organs occur on them. In spite, however, of the fact that the exclusion of the fertilizing pollen of the same species must here certainly be most perfect, the plants cultivated at Kew annually ripen an abundance of seeds, from which even the third or fourth generation of (*female*) plants have been raised there."

The correctness of the conclusion was shown farther by an actual microscopic examination of the stigmas. The same paper gives details tending to sustain the conclusion that parthenogenesis occurs in the common Hemp (*Cannabis sativa*).

* Ann. and Mag. of Nat. Hist. 1852.

It would appear from observed facts, that among some of the lower animals, it is of no more account for one of them to bud out a complete animal of its kind than for a crab to reproduce its mutilated claw. Moreover, it seems to be also true that the budding process may take place in the ovary, and that it may evolve an egg or something very like an egg, thus commencing with the first step in the reproductive process; or it may evolve a bulb-like mass from other parts of the body, like that in ordinary gemmation; and each may develop into an individual animal, or what will produce such individuals. Whether formed in one place or another, a germinating cellule, or a spot or collection of cellules, begins the development, and the whole process from its initiatory step to the end is a regular growth from the single budding individual.

Moreover, the observations in the plant kingdom appear to show definitely, (confirmatory of Mr. Lubbock's observations in the Daphnia,) that in the case of ovary reproduction, the ovule which develops without impregnation is identical in its initial growth with that prepared for impregnation according to the ordinary seed-producing process. Yet, not to lose sight of the diverse relations of the two modes of reproduction, we should remember that, normally, in every species which buds or produces budding eggs, there are also the opposite sexes for true egg-development; that even the lowest sea-weed has its conjugation of oppositely related cells for spore-reproduction; that reproduction of this one-sex kind is confined to the lower grades of species among animals, and some of these, like the Aphis, find the process so easy that they can turn off their germ-buds by the myriads, and still there is here a periodical recourse to the true sexual process; that in some animals like the Daphnia, while the ovaries produce eggs of both kinds, the normal eggs pass to another cavity and early show their distinctive character; that, in fine, a distinction of sex (a kind of sexual polarity) is the grand universal law for reproduction in life, and is never altogether set aside even for the inferior species, while absolutely essential in the higher. Moreover this supplemental and inferior means of propagation, or budding, is but an expansion of the ordinary law of growth: the same law that reproduces the nails and hair in man, the tail of a mutilated snake, or the legs of a maimed crustacean, evolves the polyp from the bud of a polyp, the Aphis from the Aphis germ-bud, or the plant from an unimpregnated ovule. The Aphis germ-bud or the unimpregnated ovule may be considered as only a minuter or more concentrated form of the bulb or bulbel.

The process by which the female produces the ovule which is afterwards to be impregnated is essentially a budding process, and not until after impregnation does it become in any case a

true developing egg; and it would seem that in a few cases, at least, it may develop either gemmately, or in true egg style, that is, it may continue a germ-bud or become an egg, according as it is or is not impregnated.

But while this extension of the budding method of propagation subserves an end of vast importance among the inferior animals and in the plant kingdom, it cannot be properly an equivalent to the normal sexual process. There is some great difference between what the female can bud out of herself, and what the sexes combined produce. It is probable from facts which have been observed both in plants and animals—though not yet demonstrated—that bud propagation will in all cases, if followed exclusively, end in the decline of the race, and its ultimate extinction; and that the sexes are required to keep up the sexual system and thus to sustain the type at its normal level and secure its perpetuity. This, if established as a real effect, is yet but a partial or inadequate expression of the difference between the two results. The subject opens a wide field for exploration.

One point seems clear, that the facts which are coming to light are calculated largely to extend and define former views, not to upset them. J. D. D.

---

## Art. XXXIII.—*Correspondence of M. Jerome Nicklès, dated Paris, July* 2, 1857.

*Obituary.*—Three deaths of men of high importance in the scientific world, Cauchy, Thenard and Colla, have taken place since our last communication, two of them, in particular, an irreparable loss to science. We mention at this time some details respecting Cauchy, reserving for a future occasion our remarks on Thenard. M. Colla, director of the observatory at Parma, died rather suddenly at the age of fifty-one years, and though less eminent than the two just mentioned, his decease has occasioned no less regret.

Augustin Cauchy was born in August, 1789. He pursued his education for a while in the Polytechnic School, and at eighteen years of age left to enter the Department of Engineering. Soon after, he made his first publications, commencing with a chef-d'œuvre, a demonstration of Euler's celebrated theorem on Polyhedrons, supplying thus what had been wanting in geometry for 2000 years. Soon after, he gave a complete demonstration of one of the theorems left by Fermat to his successors, which the best geometers had hitherto demonstrated only as regards some particular cases. He brought out a beautiful theorem, on the number of values which a function can have when we permute its letters in all possible ways. This theorem enabled Abel, twenty years later, to prove that algebraic equations of the fifth and higher degrees could not be resolved.

Having been made a member of the Academy of Sciences in 1816, in place of the great Carnot, whom the government of the Bourbons had sent

into exile, Cauchy continued his publications with his former zeal. He issued five volumes of "Exercises Mathematiques," entirely his own, while at the same time he was performing the duties of Professor of Analysis and Mechanics in the Polytechnic School, supplying the chair of Poisson in Analytical Mechanics at the Faculty of Sciences, and also working upon his *Traité d'Analyse Algebrique*, and his *Leçons de Calcul differentiel et integral*, with three volumes of *Applications*. There are few questions in pure analysis or analysis applied to physics, mechanics or astronomy, on which he has not left traces of his rare penetration and superior talent.

A devoted partisan of the Bourbon dynasty, he followed it voluntarily into exile, and for some time occupied himself only with literature and poetry and the scientific education of the Count de Chambord. In 1837, he returned to France, when he resumed his academic chair, which, contrary to the rules, had been left vacant, protected from intrusion by the admiration which his genius had inspired.

With an active imagination, he rarely completed the works he began. He made a vow over the tomb of his father, that he would not permit himself to be led away by the fertility of his mind from finishing what he undertook: but notwithstanding his respect for the memory of his father, he did not keep his vow,—which is little surprising, considering that his temperament was so opposed to confinement for any length of time to one subject.

The name of Cauchy will remain associated with the greatest conquests in modern transcendental analysis. His determination of the number of real and imaginary roots of algebraic equations; his rigorous method of calculation by approximation for these same roots; his new theory of the symmetrical functions of the coefficients of equations of any degree; his mathematical theory of light, and particularly of dispersion, including his a-priori valuation without any previous photometric experiment and no data but two angles, sustain the exalted reputation with which he entered on his career.

But with a singularity not without parallel, he thought less of his mathematical genius and scientific works than of the scraps of poor verses which he composed at his leisure. He was not confident of being a good mathematician, while sure he was a great poet.

Augustin Cauchy died suddenly on the 23d of May, in consequence of a catarrhal affection which at first seemed of little moment, and which had not prevented his occupying himself to the last with a memoir that he read to the Academy on the 4th of the month. This memoir was on the use in astronomy of regulating coefficients, ("regulateurs coefficients"), an artifice in calculation on which he rested the highest hopes, classing it among the greatest discoveries.

*Statues of Gay Lussac and Etienne Geoffroy St. Hilaire.*—Gay Lussac died in 1851. Soon afterwards it was proposed to erect a monument to one who had rendered so eminent service to both theoretical and practical physics and also to chemistry. But his family, which was rich, objected to a subscription in its behalf; and they will erect one at their own expense. It will stand on the square between the Collège de France and the Sorbonne, in both of which institutions he was for a long time Professor.

Etienne Geoffroy St. Hilaire, who died in 1844, was not only the worthy rival of Cuvier, but he appreciated Cuvier before he did himself; he attracted him to Paris, and opened to him his career and education. His works are characterized by philosophical thought and a power of generalization which are becoming daily more appreciated. He was thus the means of creating two sciences, Philosophical Anatomy and Teratology. The monument to his memory will be erected at Etampes, where he was born in 1772. The expenses will be borne by a subscription.

*History of Science. The Natural Method in Botany and Zoology.*—All botanists are not of the opinion that the natural classification of plants by Jussieu is a work that will endure. It is true that the number thus thinking is a very small minority. Among them is M. Payer, a young botanist, who quite recently declared to the Academy of Sciences that the Jussieu system is an edifice tottering to its ruin. This opinion is not shared by his associates. The botanists present at the session, among them DeCandolle, protested against it, all agreeing that while Jussieu's system had undergone modifications made necessary by the progress of the science, it still stood, as chemical nomenclature stands to the honor of Lavoisier and Guyton Morveau. However an interesting fact was elicited by the discussion. It relates to the important part which Linnæus took in the establishment of the natural method in botany as well as in zoology. This was long since brought out by Geoffroy St. Hilaire.

Most authors date the natural system in zoology from a paper published by Cuvier and St. Hilaire in 1795. That system underwent three revisions by Cuvier, and in each he approximated to the Linnæan system; and finally he ended in reconstructing that system entire. G. St. Hilaire, perceiving the accordance, mentioned it to Cuvier; this was in 1827. The great zoologist was surprised, for he had thought that he had been following the ideas of Jussieu, and supposed he was going in an opposite direction from Linnæus. The following are the two classifications, as given by M. Geoffroy.

| Classification of Linnæus. | Classification of Cuvier. |
|---|---|
| I. Primates. | II. Quadrumanes (Quadrumana). |
| II. Bruta. | V. Edentés (Edentata). |
| III. Feræ. | III. Carnassiers (Carnivora). |
| IV. Glires. | IV. Rongeurs (Rodentia). |
| V. Pecora. | VII. Ruminants (Ruminantia). |
| VI. Belluæ. | VI. Pachydermes (Pachydermata). |
| VII. Cetæ. | VIII. Cetacées (Cetacea). |

The first order in Cuvier's system included the Bimana (Man).

*Theory of Substitutions.*—The theory of substitutions has been attributed by some to Dumas, and by others to Laurent, and others still to Gay Lussac. This question of priority, discussed by Laurent in his *Méthode de Chimie*, p. 241, has been recently taken up by Dumas, who has established the precise facts upon exact documentary evidence. It appears that the first idea of substitution is due to Dumas, who, on the 13th of January, 1834, made the formal statement that, "*when a hydrogenated substance is subjected to the action of any dehydrogenating substance, it takes up a portion of the latter, equivalent to that of the hydrogen lost.*" Dumas at this same time designated this class of phenomena

by the word *metalepsy*, an expression which has been attributed to Berzelius.

But the theory of substitutions required for its completion a correct knowledge of the part in the changes played by chlorine. It will be remembered that the idea of Laurent that "in the bodies obtained by substitution, chlorine not only takes the place of hydrogen, but acts the same part with it," met with general denunciation. It was followed by the bitter criticisms of Berzelius, Liebig, and Wöhler, and a declaration by Dumas disclaiming all participation in the view, which he called an "exagération outrée de sa théorie."

For some time Laurent was alone: but after a while his time of triumph came. The theory was then attributed wholly to him. But the note published by Dumas in the Annales de Chimie et de Physique, dispels all doubts and leads to justice being rendered to each of the two chemists,—to Dumas who opened the way, and to Laurent who established the theory and rendered it of practicable value.

*Electric illumination.*—We have spoken of the experiments in electric illumination made at Lyons by Lacassaigne and Thiers. They have continued their trials with great success, and through the month of March lighted one of the principal streets of Lyons, between the hours of seven to eleven. Two pieces of apparatus set up at the extremities of the street upon a frame crossing between the roofs of the opposite houses, sent their beams down the middle of the street. The gas was not lit; all the illumination was obtained from the battery. The Rue Imperial is about 550 yards long, and is lighted with more than forty jets of gas; and yet, the gas light was fully replaced by the electric light. Something still remains to be done. It is important that the light should come from a much greater height, that it may be more diffused, and less blinding and fatiguing to the sight.

*Atmospheric electricity. Theory of thunder.*—Among the theories of thunder, the recent one of M. Jobard, Director of the Museum of Industry of Brussels, should be counted; it may be called the chemical theory. According to it, thunder is nothing but the detonation of a detonating mixture of hydrogen gas, more or less carburetted, along with atmospheric air. The gas comes from decomposing organic matters and goes up in "pluies ascendants." Moreover he assumes that the same gas sustains the clouds, the water vesicles being filled with it. M. Jobard's fertile mind is so pressed with making theories for every thing that it does not give time for verifying them. He gets rid of the hydrogen again by supposing it to form water; and also *ammonia with the nitrogen* of the air.

*New anesthetic agents.*—Besides other agents proposed for replacing ether and chloroform in anesthesis, amylene ($C^{10}H^{10}$) has been proposed. It was discovered in 1844 by M. Balard, Professor in the Faculty of Sciences at Paris. It was first applied by Mr. John Snow, and for a while produced considerable sensation in the medical world. It may be questioned however whether it is better than aldehyde, artificial oil of naphtha, Dutch liquid, and other bodies of the class of ethers or hydrocarbons, which have been set down, on examination, as inferior to chloroform. However, according to the experiments at Paris of Dr. Geraldès, the amylenic anesthesis is more easily obtained than that by means of

chloroform; it is not preceded by convulsions, muscular contractions or stiffness of the limbs; the return to sensibility is prompt and complete; the action is quicker, but it is dissipated sooner, so that the breathing of the amylene must be carried on through the operation. Moreover, as amylene is very volatile (boiling at 31° C.), it is necessary in order to produce the respiration of it to return to the old methods, of late abandoned. If free from fatal mishaps in its use, there would be a disposition to favor it. But a disaster has just occurred in the hands of Mr. Snow, and this has deprived it of its highest recommendation, its innocuousness. It has been found that this amylene contains some amylic alcohol:—see beyond on the preparation of amylene.

*Anesthesis by the Oxyd of Carbon.*—This gas is used only externally, and on the diseased part. From the experiment by the unfortunate Chenot on himself, we know that internally it is a poison. According to the trials of M. Tourdis, of the Faculty of Medicine of Strasbourg, and afterwards of Dr. Ozanam, it has no effect when applied to the skin, unless the epidermis has been previously removed. But when applied to the skin from which the epidermis is removed or to a wound or sore, it acts efficaciously and produces perfectly the anesthetic effect; and in the clinics at Strasbourg, satisfactory results have been obtained. We add that ammonia appears to be an antidote to oxyd of carbon.

*Anesthesis by Carbonic acid.*—A physician at Paris, Dr. Follin, has recently endeavored to alleviate pain by means of a continued stream of carbonic acid gas. After the discovery of gases by chemistry, towards the close of the last century, medical men in England early undertook to examine the curative properties of different gases. The first experiments were made by Ingenhousz. He made known that a finger, when the epidermis was removed, had the pain increased by oxygen, but diminished and after a while removed by nitrogen, carbonic acid or hydrogen. This fact, according to this author, was then known in France, where it had been first observed.

It was soon after made useful in therapeutics; carbonic acid was recognized as the most effective gas for removing pain, and was employed with success in several cases of ulcers. But from 1794 to 1834, the facts seem to have been forgotten. At the latter date, M. Mojon, Professor at Genoa, proposed the use of this gas anew.

Dr. Follin was led to undertake his experiment from a knowledge of some recent trials by Dr. Simpson of Edinburg. He has applied a douche of the gas with success for the relief of pain, in the case of three females having an ulcerated cancer of the neck of the womb. Quiet followed the application in a few seconds and continued, in one case, for ten to twelve hours when a new application was required; in a second, eight days; and in the third, an intermediate interval between the other two. There was, however, no curative effect, which is not remarkable. Others have repeated the experiments. The gas must of course be made pure from any muriatic acid vapor, which may be effected by passing it through a concentrated solution of carbonate of soda. Dr. Follin prefers bicarbonate of soda for obtaining the carbonic acid, which he decomposes by means of tartaric acid.

*Preparation of Amylene.*—Dr. Duroy of Paris, who has been studying the best method of preparing amylene, states that there is great difficulty

in obtaining it pure. In the amylene of different shops, he has found the boiling point vary from 30° C. to 60° C., and has detected also the presence of more or less amylic alcohol which had escaped the action of the chlorid of zinc. The amylene received from Dr. Snow, varied in its point of ebullition from 30° to 46° C.; and besides, three grams treated with potassium disengaged sixty-four cubic centimeters of hydrogen, evidence that the liquid was oxygenated.

The author observed, at first, that on exposing amylic alcohol to dry chlorid of zinc, the alcohol gave the largest proportion of amylene, and that then it dissolves about one-tenth of its weight in chlorid. With the moist chlorid the amount of amylene is a little less, but the odor not so disagreeable. In either case, the author performs the distillation in a copper alembic, arranging the whole, as in Scottman's apparatus for ether. The product volatilized contains much amylic alcohol; it is rectified by several treatments with a dilute solution of chlorid of zinc, until potassium no longer disengages hydrogen, and then it is distilled from a water-bath, collecting only that which passes over at 30° C.

*Miscellaneous Researches.* (1.) *Siliciuret of hydrogen.*—Among the new facts of special interest in chemistry recently brought out, is the obtaining of the siliciuret of hydrogen, by MM. Wöhler and Buff, by passing an electric current through a solution of chlorid of sodium by means of electrodes made of siliciuretted aluminium. The gas inflames on contact with the air, and burns with a white flame, giving up silica. On passing it through an incandescent tube of glass, there is a deposit of amorphous silicium; and a deposit is also obtained when the flame is cut off by a porcelain capsule.

(2.) *Formation of Cane sugar from Glycerine, of Mannite, etc.*, by Berthelot.—After having succeeded in making glycerine and mannite to ferment, Berthelot thinking that before entering into fermentation, they probably pass to the state of *glucose*, a state which should be preceded by that of cane sugar, tried a great number of animal membranes and azotized ferments, and ended in finding in the testicular tissue a material fitted to produce rapidly this fermentation after it had been prepared by a previous contact with a fermenting substance.

(3.) *Researches on Tungsten.*—These researches were undertaken by M. Riche, Superintendent of the Chemical works of the Faculty of Science at Paris, to establish the position of tungsten in the series of simple bodies. According to him, it is a metalloid rather than a metal; and he concludes that although differing in some characters from boron and silicon, *it should be arranged along side of these metalloids.*

Bibliography. *Flore de Lorraine;* by A. Godron, Dean and Professor of Natural History of the Faculty of Sciences of Nancy. 2 vols. in 12mo, 2nd edition. Paris: chez J. B. Baillière.—M. Godron is one of the authors of the Flora of France, and the Flora of Lorraine has the characteristics distinguishing that great work. It contains also an exact account of the geological constitution of the regions growing the more prominent species of plants; and as the author believes that the chemical constitution of the soil exerts an important influence on growth, this point is also considered. The work was prepared especially for the students of the Faculty of Sciences of Nancy. It contains an analytical table as a guide to the families.

*Etudes et Lectures sur les Sciences d'Observation et leurs applications pratiques;* by M. Babinet. 3d vol. Paris: chez Mallet-Bachelier.—In this third volume, the author presents for popular reading, many subjects of importance, as follows. 1st. The Diamond and Precious Stones; 2d. Light-houses and artificial lights; 3d. Physics of the Globe (made up from the works of Mrs. Somerville); 4th. Quilliboeuf (consisting of results of meteorological researches by M. Babinet at the mouth of the Seine); 5th. The Mediterranean; 6th. On the Plurality of Worlds.

*On the Growth of Wheat and on the Combined nitrogen in soils;* by Lawes and Gilbert. 8vo, London. *On some Points in the Composition of Wheat grain*, its products in the Mill and Bread; by Lawes and Gilbert. 8vo.—Messrs. Lawes and Gilbert do not attribute to nitrogen in farina the importance acceded to it by chemists generally. They think that what is of special importance in aliments is a large proportion of the respiratory elements. The two pamphlets mentioned contain numerous analyses of the highest interest to agriculture and chemical science. Thus it is seen that both in Europe and America the proportion of gluten increases gradually in going from the north to the south; and that the quantity and quality of the ash which vary greatly when the crop is poor, seem to have in fully matured crops a uniformity of composition and of proportion which is very remarkable and almost independent of the nature of the manures used.

*Maladie de la Pomme de Terre, de la Betterave, du Blé, et de la Vigne, de 1849 à 1853;* par Payen. 1 vol., 12mo. Paris: chez Hachette.—Besides giving the history of the disease which has ravaged the crops of Europe, this small book points out the means for resisting it with success. Payen is member of the agricultural section of the Institute and General Secretary of the Central Society of Agriculture, and is in a better position than any one else to be well posted up in all that relates to agriculture.

*La Baltique;* par Leouzon le Duc. In 12mo. Paris: chez Hachette.—The author has for a long time lived in the Scandinavian countries. His work treats of the history of these countries from a political, literary, scientific and industrial point of view. The whole is clearly presented and in excellent taste. The work serves as a complement to the following—

*Histoire des Etats Scandinaviens, Suède, Norwège et Danemark;* par M. Geoffroy, Professor in the Faculty of Letters at Bordeaux. 1 vol., contenant 5 cartes, 2 plans et une gravure.

*L'Histoire d'Angleterre, comprenant celle de l'Ecosse, de l'Islande et des Possessions Anglaises;* par Fleury.—This subject is taken up from the same point of view as the above; and to the political and geographical divisions is added a literary and scientific, with a chapter on the part which the Anglo-saxon race has taken in the progress of human knowledge and in existing civilization.

*La Musique mise a la portée de tout le Monde;* par Fetis, Directeur du Conservatoire de Musique de Bruxelles. 1 vol., 2d ed. Paris: chez Hachette.—M. Fetis in his work presents with great simplicity the principles required to enable one to speak and judge of music without profound study. He commends it not only to the popular reader but to men of science, and especially to medical men who should understand the principles of acoustics.

*Extracts from the Address of the President of the British Association, Rev.* HUMPHREY LLOYD, *at the Meeting, Aug.* 26, 1857.

*Astronomy.*—The career of planetary discovery, which began in the first years of the present century, and was resumed in 1845, has since continued with unabated ardor; and since 1846 not a single year has passed without some one or more additions to the number of the planetoids; in one year alone (1852), no fewer than *eight* such bodies were discovered. The last year has furnished its quota of *five*, and in the present *three* more have been found, one by Mr. Pogson, of Oxford, and the other two by M. Goldschmidt, of Paris. The known number of these bodies is now forty-five. Their total mass, however, is very small. The diameter of the largest is less than forty miles, while that of the smallest (Atlanta) is little more than four.

These discoveries have been facilitated by star-maps and star-catalogues, the formation of which they have, on the other hand, stimulated. Two very extensive works of this kind are now in progress—the Star-Catalogue of M. Chacornac, made at the observatory of Marseilles, in course of publication by the French Government; and that of Mr. Cooper, made at his observatory at Markree, in Ireland, which is now being published by the help of the Parliamentary Grant of the Royal Society. It is a remarkable result of the latter labor, that no fewer than seventy-seven stars, previously catalogued, are now missing. This, no doubt, is to be ascribed in part to the errors of former observations; but it seems reasonable to suppose that, to some extent at least, it is the result of changes actually in progress in the Sidereal System. The sudden appearance of a new fixed star in the heavens, its subsequent change of lustre, and its final disappearance, are phenomena which have at all times attracted the attention of astronomers. About twenty such have been observed. Arago has given the history of the most remarkable, and discussed the various hypotheses which have been offered for their explanation. Of these, the most plausible is that which attributes the phenomenon to unequal brightness of the faces of the star which are presented successively to the earth by the star's rotation round its axis. On this hypothesis the appearance should be *periodic*. M. Goldschmidt has recently given support to this explanation, by rendering it probable that the new star of 1609 is the same whose appearance was recorded in the years 393, 798, and 1203. Its period in such case, is $405\frac{1}{2}$ years.

The greater part of the celestial phenomena are comprised in the movements of the heavenly bodies and the configuration depending on them; and they are for the most part reducible to the same law of gravity which governs the planetary motions. But there are appearances which indicate the operation of other forces, and which, therefore, demand the attention of the physicist—although, from their nature, they must probably long remain subjects of speculation. Of these, the spiriform nebulæ, discovered by Lord Rosse, have been already referred to from this chair, as indicating changes in the more distant regions of the universe, to which there is nothing entirely analogous in our own system. These appearances are accounted for, by an able anonymous writer, by the action of gravitating forces combined with the effects of a resisting medium—the

resistance being supposed to bear a sensible proportion to the gravitating action.

The constitution of the central body of our own system presents a nearer and more interesting subject of speculation. Towards the close of the last century many hypotheses were advanced regarding the nature and constitution of the sun, all of which agreed in considering it an opaque body, surrounded at some distance by a luminous envelope. But the only certain fact which has been added to science in this department is the proof given by Arago that the light of the sun emanated (not from an incandescent solid, but) from a gaseous atmosphere, the light of incandescent solid bodies being *polarized by refraction*, while the light of the sun, and that emitted by gaseous bodies, is *unpolarized*. According to the observations of Schwabe, which have been continued without intermission for more than thirty years, the magnitude of the solar surface obscured by spots increases and decreases *periodically*, the length of the period being 11 years and and 40 days. This remarkable fact, and the relation which it appears to bear to certain phenomena of terrestrial magnetism, have attracted fresh interest to the study of the solar surface; and, upon the suggestion of Sir John Herschel, a photoheliographic apparatus has lately been established at Kew, for the purpose of depicting the actual macular state of the sun's surface from time to time. It is well known that Sir William Herschel accounted for the solar spots by currents of an elastic fluid ascending from the body of the sun, and penetrating the exterior luminous envelope. A somewhat different speculation of the same kind has been recently advanced by Mosotti, who has endeavored to connect the phenomena of the solar spots with those of the *red protuberances* which appear to issue from the body of the sun in a total eclipse, and which so much interested astronomers in the remarkable eclipse of 1842.

Next to the sun, our own satellite has always claimed the attention of astronomers, while the comparative smallness of its distance inspired the hope that some knowledge of its physical structure could be attained with the large instrumental means now available. Accordingly, at the Meeting of the Association held at Belfast in 1852, it was proposed that the Earl of Rosse, Dr. Robinson, and Prof. Phillips be requested to draw up a Report on the physical character of the moon's surface, as compared with that of the earth. That the attention of these eminent observers has been directed to the subject, may be inferred from the communication lately made by Prof. Phillipps to the Royal Society on the mountain Gassendi, and the surrounding region. But I am not aware that the subject is yet ripe for a Report.

I need not remind you that the moon possesses neither sea nor atmosphere of appreciable extent. Still, as a negative, in such case, is relative only to the capabilities of the instruments employed, the search for the indications of a lunar atmosphere has been renewed with every fresh augmentation of telescopic power. Of such indications, the most delicate, perhaps, are those afforded by the occultation of a planet by the moon, The occultation of Jupiter, which took place on the 2nd of January last, was observed with this reference, and is said to have exhibited no *hesitation*, or change of form or brightness, such as would be produced by the

refraction or absorption of an atmosphere. As respects the sea, the mode of examination long since suggested by Sir David Brewster is probably the most effective. If water existed on the moon's surface, the sun's light reflected from it should be completely polarized at a certain elongation of the moon from the sun. No traces of such light have been observed; but I am not aware that the observations have been repeated recently with any of the larger telescopes.

It is now well understood that the path of astronomical discovery is obstructed much more by the earth's atmosphere than by the limitation of telescopic powers. Impressed with this conviction, the Association has, for some time past, urged upon Her Majesty's Government the scientific importance of establishing a large reflector at some elevated station in the southern hemisphere. In the mean time, and to gain, as it were, a sample of the results which might be expected from a more systematic search, Prof. Piazzi Smyth undertook, last summer, the task of transporting a large collection of instruments—meteorological and magnetical, as well as astronomical—to a high point on the Peak of Teneriffe. His stations were two in number, at the altitudes above the sea of 8,840 and 10,700 feet respectively; and the astronomical advantages gained may be inferred from the fact, that the heat radiated from the moon, which has been so often sought for in vain in a lower region, was distinctly perceptible, even at the lower of the two stations.

*Figure of the Earth and the Tides.*—The researches relative to the *Figure of the Earth* and the *Tides* are intimately connected with Astronomy, and next claim our attention. The results of the Ordnance Survey of Britain, so far as they relate to the earth's figure and mean density, have been lately laid before the Royal Society by Col. James, the Superintendent of the Survey. The ellipticity deduced is $\frac{1}{299 \cdot 33}$. The mean specific gravity of the earth, as obtained from the attraction of Arthur's Seat, near Edinburgh, is 5·316; a result which accords satisfactorily with the mean of the results obtained by the torsion balance. Of the accuracy of this important work, it is sufficient to observe, that when the length of each of the measured bases (in Salisbury Plain and on the shores of Lough Foyle) was computed from the other, through the whole series of intermediate triangles, the difference from the measured length was only five inches in a length of from five to seven miles. Our knowledge of the laws of the *Tides* has received an important accession in the results of the tidal observations made around the Irish coasts in 1851, under the direction of the Royal Irish Academy. The discussion of these observations was undertaken by Prof. Haughton, and that portion of it which relates to the diurnal tides has been already completed and published. The most important result of this discussion, is the separation of the effects of the sun and moon in the diurnal tide—a problem which was proposed by the Academy as one of the objects to be attained by the contemplated observations, and which has been now for the first time accomplished.

From the comparison of these effects, Prof. Haughton has drawn some remarkable conclusions relative to the mean depth of the sea in the Atlantic. In the dynamical theory of the tides, the ratio of the solar to the lunar effect depends not only on the masses, distances, and periodic times, of the two luminaries, but also on the depth of the sea; and this,

accordingly, may be computed when the other quantities are known. In this manner, Prof. Haughton has deduced from the solar and lunar co-efficients of the diurnal tide a mean depth of 5·12 miles—a result which accords in a remarkable manner with that inferred from the ratio of the semi-diurnal co-efficients, as obtained by Laplace from the Brest observations. The subject, however, is far from being exhausted. The depth of the sea, deduced from the solar and lunar *tidal intervals*, and from *the age* of the lunar diurnal tide, is somewhat more than double of the foregoing; and the consistency of the individual results is such as to indicate that their wide difference from the former is not attributable to errors of observation. Prof. Haughton throws out the conjecture that the depth, deduced from the tidal *intervals* and *ages*, corresponds to a different part of the ocean from that inferred from the *heights*.

*Terrestrial Magnetism.*—The phenomena of *terrestrial magnetism* present many close analogies with those of the tides; and their study has been, in a peculiar manner, connected with the labors of this Association. To this body, and by the hands of its present General Secretary, were presented those reports on the distribution of the terrestrial magnetic force which re-awakened the attention of the scientific world to the subject. It was in the Committee-rooms of this Association that the first step was taken towards that great magnetic organization which has borne so much fruit; it was here that the philosophical sagacity of Herschel guided its earlier career; and it was here again that the cultivators of the science assembled, from every part of Europe, to deliberate about its future progress. It was natural, therefore, that the results obtained from such beginnings should form a prominent topic in the addresses which have been annually delivered from this chair; and the same circumstances will plead my excuse, if I now revert to some of them which have been already touched upon by my predecessors.

It has been long known that the elements of the earth's magnetic force were subject to certain regular and recurring changes, whose periods were, respectively, a *day* and a *year*, and which, therefore, were referred to the sun as their source. To these periodical changes Dr. Lamont, of Munich, added another *ten years*, the diurnal range of the magnetic declination having been found to pass from a maximum to a minimum, and back again, in about that time. But besides these slow and regular changes, there are others of a different class, which recur at *irregular* intervals, and which are characterized by a large deviation of the magnetic elements from their normal state, and generally also by rapid fluctuation and change. These phenomena, called by Humboldt "magnetic storms," have been observed to occur *simultaneously* in the most distant parts of the earth, and thus to indicate a cause operating upon the entire globe. But, casual as they seem, these effects are found to be subject to laws of their own. Prof. Kreil was the first to discover that, at a given place, they recurred more frequently at certain hours of the day than at others; and that, consequently, in their mean effects, they were subject to periodical laws, depending upon the *hour* at each station. The laws of this periodicity have been ably worked out by General Sabine in his discussion of the results of the British Colonial Observatories; and he has added the important facts, that the same phenomena observe also the two

other periods already noticed,—namely, the *annual* and the *decennial* periods. He has further arrived at the very remarkable result, that the decennial magnetic period coincides, both in its duration and in its epochs of maxima and minima, with the decennial period observed by Schwabe in the solar spots; from which it is to be inferred that the sun exercises a magnetic influence upon the earth dependent on the condition of the luminous envelope.

We are thus in the presence of two facts, which appear at first sight opposed—namely, the absolute simultaneity of magnetic disturbances at all parts of the earth, and their predominance at certain local hours at each place. General Sabine accounts for this apparent discrepancy by the circumstance, that the hours of maximum disturbance are different for the different elements; so that there may be an abnormal condition of the magnetic force, operating at the same instant over the whole globe, but manifesting itself at one place chiefly in one element, and at another place in another. I would venture to suggest, as a subject of inquiry, whether the phenomena which have been hitherto grouped together as "occasional" effects may not possibly include two distinct classes of changes, obeying separate laws: one of them being strictly periodic, and constituting a part of the regular diurnal change; while the other is strictly abnormal, and simultaneous at all parts of the globe. If this be so, it would follow that we are not justified in separating the larger changes from the rest, merely on the ground of their magnitude, and that a different analysis of the phenomenon is required. The effects hitherto considered are all referable to the sun as their cause. Prof. Kreil discovered, however, that another body of our system—namely, our own satellite—exerted an effect upon the magnetic needle, and that the magnetic declination underwent a small and very regular variation, whose amount was dependent on the lunar hour-angle, and whose period was therefore a lunar day. This singular result was subsequently confirmed by Mr. Broun in the discussion of the Makerstoun Observations; and its laws have since been fully traced, for all the magnetic elements, by General Sabine, in the discussion of the results obtained at the Colonial Magnetic Observatories.

The foregoing facts bear closely upon the debated question of the causes of the magnetic variations. It has been usual to ascribe the periodical changes of the earth's magnetic force to the thermic action of the sun, operating either *directly* upon the magnetism of the earth, or affecting it *indirectly* by the induction of the thermo-electric currents. Here, however, we have a distinct case of magnetic action, unaccompanied by heat; and the question is naturally suggested, whether the larger diurnal change may not also be independent of temperature. The most important fact, in its bearing upon this question, is the existence of an *annual inequality* in the diurnal variation, dependent on the sun's declination, which has been recently pointed out by General Sabine. If we deduct the ordinate of the curve which represents the mean diurnal variation for the entire year, from those of the summer and winter half-yearly curves respectively, the differences are found to be equal and opposite; and the curves themselves, consequently, are *similar*, but *oppositely placed*, with respect to the axis of abscissæ. From this, General Sabine draws

the inference, that the diurnal variation is a direct effect of solar action, and not a result of its thermic agency.

*Light.*—The most important of the recent additions to the theory of *Light* have been those made by M. Jamin. It has been long known that metals differed from transparent bodies, in their action on light, in this, that plane-polarized light reflected from their surfaces became *elliptically polarized ;* and the phenomenon is explained on the principles of the wave-theory, by the assumption that the vibration of the ether undergoes a *change of phase* at the instant of reflexion, the amount of which is dependent on its direction and on the angle of incidence. This supposed distinction, however, was soon found not to be absolute. Mr. Airy showed that *diamond* reflected light in a manner similar to metals; and Mr. Dale and Prof. Powell extended the property to all bodies having a high refractive power. But it was not until lately, that M. Jamin proved that there is *no distinction* in this respect between transparent and metallic bodies; that all bodies transform plane-polarized into elliptically-polarized light, and impress a change of phase at the moment of reflexion. Prof. Haughton has followed up the researches of M. Jamin, and established the existence of *circularly-polarized* light by reflexion from transparent surfaces.

The theoretical investigations connected with this subject afford a remarkable illustration of one of those impediments to the progress of Natural Philosophy which Bacon has put in the foremost place among his examples of the *Idola*—I mean the tendency of the human mind to suppose a greater simplicity and uniformity in nature than exists there. The phenomena of polarization compel us to admit that the sensible luminous vibrations are *transversal*, or in the plane of the wave itself; and it was naturally supposed by Fresnel, and after him by M'Cullagh and Neumann, either that no *normal* vibrations were propagated, or that, if they were, they had no relation to the phenomena of light. We now learn that it is by them that the *phase* is modified in the act of reflexion; and that, consequently, no dynamical theory which neglects them, or sets them aside, can be complete.

Attention has been lately recalled to a fundamental position of the wave-theory of light, respecting which opposite assumptions have been made. The vibrations of a polarized ray are all parallel to a fixed direction in the plane of the wave; but that direction may be either *parallel* or *perpendicular* to the plane of polarization. In the original theory of Fresnel, the latter was assumed to be the fact; and in this assumption Fresnel has been followed by Cauchy. In the modified theories of M'Cullagh and Neumann, on the other hand, the vibrations are supposed to be parallel to the plane of polarization. This opposition of the two theories was compensated, as respects the results, by other differences in their hypothetical principles; and both of them led to conclusions which observation has verified. There seemed, therefore, to be no means left to the theorist to decide between these conflicting hypotheses, until Prof. Stokes recently, in applying the dynamical theory of light to other classes of phenomena, found one in which the effects should differ on the two assumptions. When light is transmitted through a fine grating, it is turned aside, or *diffracted*, according to laws which the wave-theory has

explained. Now, Prof. Stokes has shown that, when the incident light is *polarized*, the *plane of vibration* of the diffracted ray must differ from that of the incident, the two planes being connected by a very simple relation. It only remained, therefore, for observation to determine whether the *planes of polarization* of the incident and refracted rays were similarly related or not. The experiment was undertaken by Prof. Stokes himself, and he has inferred from it that the original hypothesis of Fresnel is the true one. But, as an opposite result has been obtained by M. Holtzmann, on repeating the experiment, the question must be regarded as still undetermined.

The difference in the experimental results is ascribed by Prof. Stokes to the difference in the nature of the gratings employed by himself and by the German experimentalist, the substance of the diffracting body being supposed to exert an effect upon the polarization of the light, which is diffracted by it under a great obliquity. I learn from Prof. Stokes that he proposes to resume the experimental inquiry, and to test this supposition by employing gratings of various substances. If the conjecture should prove to be well founded, it will greatly complicate the dynamical theory of light. In the mean time the hypothesis is one of importance in itself, and deserves to be verified or disproved by independent means. I would venture to suggest that it may be effectively tested by means of the beautiful *Interference-refractor* of M. Jamin, which the inventor has already applied to study the effects upon light produced by grazing a plate of any soluble substance inclosed in a fluid. It is well known that the refractive index of bodies increases with their density; and the theory of emission has even expressed the law of their mutual dependence. That theory, it is true, is now completely overthrown by the decisive *experimentum crucis* of MM. Fizeau and Foucault. It was, therefore, probable, *à priori*, that this law—the only one peculiar to the theory—should be found wanting. Its truth has recently been put to an experimental test by M. Jamin. Water, it is known, has its maximum of density at about 40° of Fahrenheit; and accordingly, if Newton's law were true, its refractive index should also have a maximum value at the same temperature. This has been disproved by M. Jamin, by observing the interference of two rays, one of which has passed through air, and the other through water; and thus the last conclusion of the emission-theory has been set aside.

It would occupy too much of your time were I to touch, even lightly, upon the subject of the chemical action of light, and the many beautiful and important discoveries of the art to which it has given rise. I may, however, mention, as one of the latest of the marvels of *photography*, that M. Poitevin has succeeded in producing plates in relief, for the purposes of engraving, by the action of light alone. The process depends upon the change in the affinity for water, produced by the action of light upon a thin plate of gelatine, which is impregnated with bichromate of potash.

# SCIENTIFIC INTELLIGENCE.

## I. CHEMISTRY AND PHYSICS.

1. *On the calculation of the densities of vapors.*—KOPP has suggested a mode of calculating the densities of vapors when referred to air as unity, which is shorter and more convenient than the ordinary process. If the equivalent of a body be referred to oxygen taken as 8, and its vapor-density to air as 1, we find that the quotient of the atomic weight by the density is equal to one of the following numbers,

28·88 14·44 7·22

The number 28·88 corresponding to a condensation of four, 14·44 to one of two, and 7·22 to one of one volume. The author calls these numbers normal quotients. When the density of the vapor of a substance has been determined approximately by experiment, the quotient of its equivalent by this density is a number which is very near one of the preceding. This operation shows at once the mode of condensation of the vapor. Conversely, it is always easy to calculate the vapor density by dividing the equivalent by one or the other of the normal quotients. Thus, for a great majority, if not for all organic compounds, the divisor is 28·88, because the substances correspond to 4 vols. Thus in the case of acetic ether we have for the equivalent 88 and for the experimental density 3·112, now $\frac{88}{3\cdot112}=28\cdot2$, a result which indicates a condensation into 4 vols. The theoretic density is therefore $\frac{88}{28\cdot88}=3\cdot047$.

This mode of calculating the vapor-density of a body does not require a knowledge of the densities of the vapors of the elements contained in the body. It is only necessary to know the equivalent of the body itself. It follows that bodies which have the same equivalent will usually have the same density of vapor. Thus phenol, $C_{12}H_6O_2$, and bisulphid of methyl, $C_4H_6S_4$, have the same equivalent, 94, and the same density, 3·255. When the densities of bodies having the same equivalent are not the same they will of course be connected by simple ratios.—*Comptes Rendus*, xliv, 1347.

[*Note.*—If we take the density as well as the equivalent and combining volume of hydrogen =1, the vapor-densities of all other gases and vapors are either equal to their equivalents or to their equivalents divided by a low number. In general terms, with these units, the vapor-densities are equal to the equivalents divided by the combining volumes. Thus the densities of *nitrogen*, *chlorine*, *iodine*, *bromine*, &c., are simply represented by their equivalents 14, 35·5, 127, 80. The vapor-density of sulphur is $\frac{16}{\frac{1}{3}}=48$, that of oxygen $\frac{8}{\frac{1}{2}}=16$. It must be remembered that upon this system 2 vols. correspond to 4 vols. upon the scale in which the density of air =1. Hence the vapor-densities of nearly all organic compounds are simply half their equivalents, when all the hydrogen constants are taken as units. If it be objected to this system that experiment always compares the weights of equal volumes of air and vapor, it

is sufficient to reply that, in calculating the result of the experiment, the ratio of the densities of air and hydrogen may always be taken, so as not to increase the labor of calculation in the least. Would not, for all chemical purposes, a single uniform system of units be preferable to a mixed system such as that which we now employ?—W. G.]

2. *On the combinations of the hydracids with hydrocarburets.*—BERTHELOT finds that the hydrocarburets homologous with olefiant gas, under the influence of heat and pressure, unite with various hydracids so as to form the chlorids, bromids, &c. of the methyl series. Thus propylene, heated for seventy hours to 100° C. with an aqueous solution of chlorhydric acid, is completely absorbed, the reaction being expressed by the equation $C_6H_6+HCl=C_6H_7Cl$.

The chlorids, iodids and bromids of amylene, caprylene, ethylene and acetene may be formed by precisely similar processes, so that it is possible to pass from the hydrocarburets to the corresponding alcohols by simple and uniform processes.—*Comptes Rendus*, xliv, 1350.

3. *On inverse substitutions.*—The same chemist has also discovered new processes by which iodine, bromine, and chlorine in organic bodies may be replaced by hydrogen. After detailing the processes employed by other chemists in effecting the same object, the author describes his own methods, which consist either in employing free hydrogen at a high temperature, or in the concurrence of two simultaneous affinities equivalent to the use of nascent hydrogen. Free hydrogen unites with the chlorine of chlorids of carbon at a low red heat, the corresponding carburet of hydrogen being regenerated. A portion of the carburet is always destroyed at the same time. Thus we have the equations

$$C_4Cl_4+8H=C_4H_4+4HCl$$
$$C_4Cl_6+10H=C_4H_4+6HCl$$
$$C_{20}Cl_8+16H=C_{20}H_8+8HCl, \text{ \&c. \&c.}$$

When bromid of ethylene, $C_4H_4Br_2$, water and iodid of potassium were heated together, hydruret of ethyl was formed, while olefiant gas, carbonic acid and oxyd, and hydrogen were also set free. The temperature should be near 275° C. and the operation conducted slowly. The bromids of propylene and amylene, when heated to 275° C. with copper, water and iodid of potassium, yield propylene and amylene. By similar processes the author obtained marsh gas from chloroform, bromoform and iodoform. Finally bichlorhydrine, $C_6H_5Cl_3$, one of the chlorhydric ethers of glycerine, yields under similar circumstances propylene, $C_6H_6$, hydruret of propyl, $C_6H_8$, hydrogen and carbonic acid.—*Comptes Rendus*, xliv, 1246, 1349.

4. *On Silicium and the metallic siliciurets.*—DEVILLE and CARON have presented to the Academy a memoir upon silicium or silicon which exhibits many points of special interest. The authors find, in the first place, that aluminium is not the only metal which possesses the property of dissolving silicon, but that zinc may also be made to act advantageously as a solvent. The preparation of crystalline silicon by means of zinc is very simple and easy of execution. An earthen crucible is to be heated to redness and a carefully made mixture of three parts of fluosilicate of potassium, one part of sodium cut in small pieces, and one part of granulated zinc is to be thrown into it. The reaction ensuing is very feeble

and not sufficient to effect the fusion of the mass. The crucible must therefore be kept at a red heat until the scoria is completely fused. The heat must not be high enough to vaporize the zinc or the operation would be lost. After slow cooling, the crucible is to be broken, when a button of zinc will be found, penetrated through its whole mass, and especially on its upper surface, by long needles of silicon. These are groups of regular octahedrons imbedded in each other parallel to the axis which unites the summits of two opposite angles. To extract these crystals, it is only necessary to dissolve the zinc in chlorhydric acid, and then boil the silicon with nitric acid. In this way, crystallized silicon can be obtained in more beautiful crystals, and in larger quantity, than by any other method. The only portion of silicon lost in this process, is that disengaged in the form of siliciuret of hydrogen at the moment of the solution of the zinc. If the alloy of zinc and silicon be heated beyond the point at which the metal volatilizes, the silicon remains in the state of a fused mass which is entirely free from zinc. Pure silicon may be fused and run into moulds. In this manner the authors prepared ingots which were presented to the Academy. The authors are now engaged in studying the alloys of silicon which appear to be of much interest. The alloys with iron are very fusible and in their physical properties resemble cast iron and steel. A very hard, brittle and white alloy of silicon and copper containing twelve per cent of silicon is prepared by fusing together three parts of fluosilicate of potash, one part of sodium, and one part of copper turnings, till a very liquid scoria is obtained. An alloy of copper and silicon containing 4·8 per cent of silicon possesses a beautiful clear bronze color. It is a little less hard than iron and may be filed, sawed, or turned, like that metal. It is perfectly ductile, and wires drawn from it are as tenacious as those of iron. The hardness of the siliciurets increases with the quantity of silicon, but at the same time their ductility diminishes. They are all characterized by the fact that silicon is uniformly distributed throughout the mass so that the alloys are homogeneous and not susceptible of liquation. The authors presented to the Academy two small cannon made of alloys of copper and silicon. They furnish examples of what may be done in the arts by the application of the alkaline metals, and of the progress which is every day making in the manufacture of sodium. The authors have not limited their experiments to silicon, but expect by similar methods to prepare other simple or compound bodies in a crystallized state.—*Comptes Rendus*, xlv, 163, *Aug.* 1857.

5. *On the oil of the Dutch chemists.*—Wurtz has communicated to the Academy a note upon this often studied substance, showing it to be the chlorid of the glycol radical, $C_4H_4$, which exists in glycolic alcohol, and which is diatomic. The chlorid is easily prepared by the action of perchlorid of phosphorus upon glycol-alcohol, the reaction being represented by the equation

$$C_4H_6O_4 + 2PCl_5 = 2HCl + 2PO_2Cl_3 + C_4H_4Cl_2.$$

The Dutch liquid bears therefore the same relation to the glycol-radical which chlorid of ethyl does to ethyl, the former being diatomic and referable to the type of four equivalents of hydrogen, so that we have

$$\left.\begin{matrix} C_4H_4 \\ H_2 \end{matrix}\right\} = \left.\begin{matrix} C_4H_4 \\ Cl_2 \end{matrix}\right\} = \left.\begin{matrix} H_2 \\ H_2 \end{matrix}\right\}.$$

The author remarks that the Dutch liquid is entirely different in properties from the isomeric body, $C_4H_4Cl.Cl$, which is obtained by the action of chlorine upon chlorid of ethyl.—*Comptes Rendus*, xlv, 228.

6. *New derivatives of salicyl and new iodids of organic radicals.*—CAHOURS has studied the action of chlorid of acetyl (acetoxyl of Kolbe), as well as of other similar chlorids upon salicylic acid, setting out from the observation of Bertagnini that chlorid of acetyl by acting upon oil of bitter almonds produces cinnamic acid, according to the equation

$$C_{14}H_6O_2 + C_4H_3O_2Cl = HCl + C_{18}H_8O_4.$$

Hydruret of salicyl is strongly attacked by the chlorid of acetyl, but the product is not an acid but a neutral substance which has the formula $C_{18}H_8O_6$, and which is not decomposed by boiling with alkaline solutions, so that it is not identical with cinnamic acid. Benzoic acid under the same circumstances yields another isomeric body, namely, aceto-benzoic acid, which under the influence of water yields benzoic and acetic acids. The chlorids of cumyl, anisyl and succinyl behave in a similar manner toward the hydruret of salicyl, and yield new bodies which the author terms cumosalicyl, anisosalicyl and succinosalicyl. The author remarks, that in these compounds the elements are not merely in juxtaposition, as in the double anhydrous acids, but are fused together so that the distinctive characters of each are lost. A theory which satisfactorily accounts for these facts is still wanting. In conclusion the author describes the iodids of several of the acetyl radicals, which he obtained by the action of iodid of phosphorus upon butyrate, acetate and valerate of potash carefully dried. The iodid of acetyl (acetoxyl) is a heavy brown liquid boiling between 104° and 105° C. The iodid of butyryl boils at 146°; that of valeryl at 168°. They are perfectly analogous, in their chemical relations, to the corresponding bromids and chlorids.—*Comptes Rendus*, xliv, 1252.

[The iodid of acetyl has also been described in the Quarterly Journal of the Chemical Society by Guthrie, who obtained it by the action of iodid of phosphorus upon anhydrous acetic acid. It is very much to be regretted that the nomenclature of Kolbe is not generally adopted, so that the term acetyl may retain the signification originally given it by Berzelius and denote the radical $C_4H_3$, while acetoxyl is applied to the secondary radical $C_4H_3O_2$.—W. G.]

7. *On the true formula of oxalic acid.*—WURTZ has endeavored to show that oxalic acid is not only to be considered as bibasic, but that it bears the same relation to glycol-alcohol which acetic acid does to ordinary alcohol. When glycol is completely oxydized, as for example, by means of platinum black, carbonic acid is disengaged and the glycol disappears. When however the glycol is previously diluted with several times its volume of water, glycolic acid is formed. Nitric acid also, when acting slowly, oxydizes glycol, producing glycolic acid, the formula of which, it will be remembered, is $C_4H_4O_6$. By the more rapid action of nitric acid, oxalic acid is produced. The following formulas exhibit the relation between glycol and the two derived acids.

| | | |
|---|---|---|
| $\left.\begin{matrix}C_4H_4\\H_2\end{matrix}\right\}O_4$, | $\left.\begin{matrix}C_4H_2O_2\\H_2\end{matrix}\right\}O_4$, | $\left.\begin{matrix}C_4O_4\\H_2\end{matrix}\right\}O_4$. |
| Glycol, | Glycolic acid, | Oxalic acid. |

These relations are the same as those between alcohol and acetic acid, since we have

$$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}O_2, \qquad \left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2.$$

The result is in all cases due to a regular oxydation or rather substitution of oxygen for hydrogen. The author considers this result as proving that oxalic acid contains four equivalents of carbon, since it is derived from olefiant gas. The other acids which are homologous with oxalic acid must be derived in a precisely similar manner from the homologues of glycol. So that according to Wurtz we have the three series,

| | | | | | |
|---|---|---|---|---|---|
| $C_2H_4O_4$ | Methylglycol | $C_2H_2O_6$ | Carbonic acid | ——— | |
| $C_4H_6O_4$ | Glycol | $C_4H_4O_6$ | Glycolic acid | $C_4H_2O_8$ | Oxalic acid |
| $C_6H_8O_4$ | Propylglycol | $C_6H_6O_6$ | Lactic acid | $C_6H_4O_8$ | ——— |
| $C_8H_{10}O_4$ | Butylglycol | $C_8H_8O_8$ | ——— | $C_8H_6O_8$ | Succinic acid |
| &c. | | &c. | | &c. | |

—*Comptes Rendus*, xliv, 1306.

[*Note.*—It may reasonably be objected to this view that with the formula $C_2H_2O_6$, carbonic acid must be bibasic. But the other acids, which, according to Wurtz, are homologous with it are monobasic. Can we have a series of homologous monobasic acids of which the first term is bibasic?—W. G.]

8. *Protosulphid of carbon.*—E. Baudrimont has discovered the sulphur compound of carbon which corresponds in constitution to carbonic oxyd. The author gives various processes for preparing this substance, the best of which consists in passing the vapor of bisulphid of carbon over spongy platinum or pumice stone heated to redness. An abundant deposit of sulphur is formed, while CS escapes as a gas. The new gas is colorless and has an odor which suggests that of the bisulphid, but which is strongly ethereal and not disagreeable. It burns with a blue flame, producing carbonic and sulphurous acids with a little sulphur. It is not liquefied by a mixture of ice and salt. Water dissolves its own volume but decomposes the gas into sulphid of hydrogen and oxyd of carbon, $HO+CS=CO+HS$. Alkaline solutions of potash and soda rapidly decompose it; thus with lime water we have the equation

$$CaO+CS=CaS+CO.$$

When the protosulphid of carbon is exposed to sunlight with an equal volume of chlorine there is a partial condensation and new products are found which the author is engaged in studying.—*Comptes Rendus*, xliv, 1000.

Persoz claims the discovery of this compound of carbon and sulphur, and refers in support of his assertion to his work on chemistry, published at Strasbourg in 1837–38.—*Comptes Rendus*, xliv, 1218.

9. *On Glyoxal and Glyoxylic acid.*—Debus has discovered among the products of the oxydation of alcohol by nitric acid, a new aldehyd which he terms *glyoxal*, and a new acid, *glyoxylic acid*. The constitution of glyoxal is represented by the formula $C_4H_2O_4$, and it is diatomic as is shown by its combinations with alkaline bisulphites. Thus the soda salt has the formula

$$C_4H_2O_4+2(NaO.SO_2+HO.SO_2)+HO.$$

Glyoxal may be obtained by decomposing the corresponding baryta salt by sulphuric acid; it affords an amorphous, transparent, faintly yellow mass which is readily soluble in water, alcohol, and ether. Its aqueous solution reduces silver from the nitrate: its solution in ether gives a white precipitate with ammonia. Caustic alkalies convert glyoxal into glycolic acid, even in the cold, and very easily on heating. Thus the reaction with lime is expressed by the equation

$$C_4H_2O_4 + CaO.HO = C_4H_3O_5, CaO.$$

Evaporated on a water-bath with a little very dilute nitric acid, glyoxal yields glyoxylic acid, $C_4H_2O_6$: much nitric acid converts this into oxalic acid, $C_4H_2O_8$. The author regards glyoxal as the aldehyd of the biacid alcohol glycol, $C_4H_6O_4 = C_4H_4O_2 + 2HO$. While however acetic aldehyd combines with only one equivalent of an alkaline bisulphite and yields on oxydation a monobasic acid, glyoxal combines with two equivalents of a bisulphite and yields on oxydation two bibasic acids. In conclusion the author points out the relations between glyoxal and certain organic acids.—*Ann. der Chemie u. Pharm.*, cii, 20.

10. *On the equivalents of Nickel and Cobalt.*—Schneider has determined the equivalents of nickel and cobalt by analyses of their oxalates, both carbon and metallic oxyd being directly determined. The author found for nickel as the mean of four experiments the equivalent 29·025, and for cobalt 30·003. These numbers may of course be taken as exactly 29 and 30, so that iron, nickel and cobalt form an ascending scale of equivalents, 28, 29, 30.—*Pogg. Ann.*, ci, 387. W. G.

## II. GEOLOGY.

1. *Geological Report of the Midland Counties of North Carolina;* by E. Emmons, illustrated with engravings, pp. 350, 1856.—Besides other matter, this Report contains the results of Dr. Emmons's Survey of the Coal Fields of North Carolina and of the sandstones associated with them. Of these, which have attracted much attention in former years, the following brief account is presented from the new light which has been shed upon both the coal fields and the sandstones.

The range of sandstones is well known to extend from the north part of Massachusetts on Connecticut River southward to Long Island Sound; to begin again on the southern part of the Hudson and continue into New Jersey, and, pursuing a course west of south, to appear in the States of Pennsylvania, Virginia, and North Carolina even into the bounds of South Carolina, though with interruptions. At the north this series was formerly called the New Red Sandstone, supposed to be geologically next above the Coal Formation, and a part of the Triassic. On the continent of Europe, the Trias is divided into *three* parts, the upper called the Keuper, the middle the Muschelkalk, and the lower the Bunter Sandstein. The Muschelkalk is wanting in England and in our country; the other two are admitted in the geology of England, and Dr. Emmons maintains the existence of both in North Carolina and at the north, as the Upper and the Lower Sandstones, separated by their peculiar conglomerates and a partial unconformability. If this is sustained, the Richmond coal field, and also that of N. Carolina, must be placed, not in the Lias, or

Oolite series, but entirely below both. In the former relation, Prof. Wm. B. Rogers placed the coal and sandstone in view of all the evidence attained in 1843. This view Sir Charles Lyell considered to be confirmed by his own subsequent special examination, as he states in his Elementary Geology, sixth edition, p. 330.

But more extensive examinations and discoveries of fossils, animal and vegetable, have changed the character and value of the evidence and led to some changes of opinions. Professor O. Heer, of the Federal Polytechnic School, Zurich, who is distinguished for his knowledge of fossil plants and insects, has carefully examined Prof. Emmons's N. Carolina Report, as well as specimens, and forwarded his conclusions and corrections, which are now before me, and have great importance in determining the geological position of the coal and the sandstone. The fossils mentioned by Prof. Heer are referred to the page of the N. Carolina Report, and his opinion given in quotation marks.

*Strangerites obliquus* Em., p. 325; "good."

*Acrostichites oblongus*, Göpp. n. sp., p. 326.—This fern has been taken for Pecopteris Whitbyensis, but is properly removed to another genus by Dr. Emmons, because it is very different, says Prof. Heer in the "form of its sori," and "bears no resemblance to fig. 2 and 4 of plate 109 of Brongniart, nor to the figure given by Lindley," of P. Whitbyensis. "It is the neuration in particular which proves their difference; for the American plant presents a neuration which is reticulated, or at least its secondary nerves are tied together, while in the English plant the secondary nerves are digital and dichotomous, without being tied together laterally."

The *P. Whitbyensis* then is not in the Richmond nor the N. Carolina Coal Field and is no evidence of their geological position.

*Pecopteris Carolinensis* Em., p. 327, is "Gutbierea Carolinensis, Heer."

*Pecopteris* (*Aspidites*) *bullatus*, Bunbury, p. 328.—Prof. Heer says this fern "resembles so closely the Pecopteris Stuttgartiensis of Brongniart that I do not hesitate to regard them as identical. It cannot be comprehended how Bunbury has failed to recognize at least the great resemblance to the European species, so abundant in the Keuper, at Stuttgart, at Bâle, at Basière, &c."

*Neuropteris linæfolia*, Bunbury, p. 329.—"It is not a Neuropteris but rather a *Cyclopteris*, resembling the C. pachyrachis, Göpp. (Fossil Genera pl. 4, fig. 13 and 14 of the Lias.")

*Pecopteris falcatus* Em., p. 327.—"It is probably a Loccopteris. It greatly resembles Loccopteris germinans of Göppert (Fossil genera, pamphlet 1 and 2, pl. 6, fig. 8.")

*Dictyocaulus striatus*, n. g., Em., p. 293.—This fossil has an obvious resemblance to Noeggerathia, p. 357 of Lyell's El. Geol., Ed. 6th, 1857.

*Pterozamites decussatus*, Em., p. 330.—Of this Cycadea, Prof. Heer writes; "Although the species is represented but by a part of a leaf, this specimen resembles so much Pterozamites longifolius that I do not doubt of their identity, that is, Pterozamites longifolius, Braun." Later specimens led Prof. Emmons to the same correction.

*Equisetum columnare*, p. 334.—Of this Calamitacæ Prof. Heer observes; "Emmons has drawn but a poor specimen, which however appears to be this species." All will coincide in this opinion who know the fossil and look at the figure.

*Calamites arenaceus*, p. 334; "good."

*Calamites disjunctus*,, Em., p. 334, "does not seem to be other than the C. arenaceus." The future will decide.

"In conclusion," says Prof. Heer, "such species as *Pterozamites longifolius*, *Equisetum columnare*, and *Pecopteris Stuttgartiensis*, are characteristic of the Keuper or Marnes Irisées of Germany, of France, and of Switzerland; some others are like species that are found in Europe in the Keuper and the inferior Lias, but are specifically different. There is no species really Oolitic in Virginia and North Carolina."

Besides the evidence from the fossil Flora, which shows the age of the Richmond and N. Carolina coal fields, there is other proof from the fossil Fauna. These are the Thecodonts, found in Europe in the Bunter Sandstein, or in the Permian, and some others.

Messrs. Riley and Stutchbury first named a *Palæosaurus* and *Thecodontosaurus* from the Bristol conglomerate, England. (See Lyell's El. Geol., 6th ed., p. 358.) Analogous remains were detected by Mr. Lea of Philadelphia in the sandstone of Milford, Penn., which he named *Clepsisaurus Pennsylvanicus*. In the Deep River and Dan River Coal field, Dr. Emmons found analogous remains, which he named *Clepsisaurus Carolinensis*, being somewhat different from that described by Mr. Lea. Another was named *C. Leai*, Em., in honor of I. Lea, the discoverer of the first "Thecodont saurians in our country." To this was added Rutiodon Carolinensis, *Em.*, and one or two species of Palæosaurus, related to the Thecodonts of the Permian in Europe.

Still more remarkable is the discovery of a mammal in the coal series of Chatham, N. C., which is named *Dromatherium sylvestre*, Em., a new genus and species of a placental insectivore associated with the Thecodont saurians.

Another letter has been recently received from Zurich, in which it is stated by Mr. Marcou that Sir Charles Lyell, after a visit of some weeks at Zurich, and a full examination of the specimens of fossils, figures, and descriptions from the Richmond and North Carolina coal series, has come to the conclusion that this group is "Permian, or else is the Bunter sandstein;" that the "Dromatherium is the most ancient mammal yet discovered;" and that he has "changed the age of the red sandstone in his German edition of the Manual of Elementary Geology, now in the course of publication at Freiburgh," and that he will "make the same change in his next English and French editions of his Manual." C. D.

Oct. 6, 1857.

*Additional Remarks by J. D. Dana.*—In the determination of the exact age of this sandstone, the only rock in this country east of the Mississippi occurring between the Carboniferous and the Cretaceous, we cannot be too cautious in the use of evidence. One or two considerations are therefore here suggested. In the first place, the Fauna and Flora of America of this modern epoch, is represented in Europe, and quite strikingly, as has been shown, by the Fauna and Flora of the later tertiary of Europe. The life of corresponding ages in the two continents has thus been older in America than in Europe. This is one point to be well weighed. Again, in determining the age of a rock from its fossils, we should rather look to those which indicate the more recent period, than those which bear the

other way. This criterion would bring us right with regard to our own epoch, while by avoiding it, we might be able to prove that we in America are of the Tertiary age of the world. Now, as Mr. Redfield has shown, the fossil fishes,—the most characteristic species of any formation,—are but *half* heterocercal and come nearer to the Jurassic type than the Triassic. There is hence reason for the opinion notwithstanding the important evidence brought forward by Dr. Emmons, that the Lias period may be represented by the formation; and we may be nearest the truth if we regard the whole formation as corresponding to the Lias and the latter half of the Trias. The examinations by Mr. Heer accord with this conclusion. The European subdivisions of the Trias we should not look for on this continent, even if we had the whole of the formation, any more than the European subdivisions of the Devonian in the American Devonian. American geology is deeply interested in the decision of this question, and owes much to Prof. Emmons for all that he has done towards its elucidation.

2. *Illustrations of Surface Geology;* by EDWARD HITCHCOCK, LL.D., Professor of Geology and Natural Theology in Amherst College. 156 pp., 4to, with 12 plates of sections, maps and views. From the ninth volume of the Smithsonian Contributions to Knowledge.—The subjects here treated under the title of Surface Geology, are, terraces, elevated beaches, drift and the associated phenomena, erosion of the surface forming valleys, and the agents of change, running water, the sea, icebergs and glaciers. The author presents the results of a large amount of personal examination made mainly in New England, though to some extent also in other countries. The heights and positions of numeous terraces along the Connecticut valley and some of its tributaries, and of some on the Merrimack river, are given in the text, and the plates contain illustrations both by sections and neat maps. The great subject of terraces, a phenomenon that characterizes the whole breadth of the continent (except perhaps at the south,) and therefore one of the grandest in the science, is approached in the right method, and an important step is taken towards solving the great problem. It is impossible in a brief notice to give a satisfactory review of the facts brought out in this long and valuable paper. We mention a few of the deductions.

1. True unstratified drift never covers the terraces; it is covered by the terrace material, and is therefore of older date.

2. The successive "beaches" and "terraces" are made out of the drift material, with few exceptions, all by essentially similar operations.

3. The river valleys were excavated before the terrace epoch, for in the rocky gorges, as at Bellows Falls, drift scratches are found near the present water level; these gorges therefore were not closed at that time by rocky barriers.

4. The highest distinct river-terraces noticed by the author in this country are as follows: at Bellows Falls, on the Connecticut, 226 feet *above the river;* on the Deerfield, 236 feet; on Genesee river (New York State) at Mount Morris, 348 feet. Above these heights, there are other levels designated *beaches*, and the most distinct of these are stated to be from 800 to 1200 feet high; while others, less distinct, are mentioned as found at 1200 to 2600 feet in the White Mountains and elsewhere.

5. The number of terraces is usually larger and the height greater on the small than on large streams; there are seldom over *three* or *four* on the Connecticut; while on some of its tributaries, there are sometimes as many as *ten*.

6. The terraces on opposite sides of the same stream very often do not correspond in elevation.

7. The terraces, in general, slope with the stream. They are usually somewhat the highest about a gorge, as if the gorge had occasioned a higher level to the river floods, and therefore more elevated depositions. They show by the stratification that they are the result of water-action; though stranded ice, it is urged, may have aided in making the variety of terrace called *moraine-terrace*.

8. The beaches also must have been produced by water, and this water must have been the ocean. "Hence I feel sure," says the author, "from the facts which I have stated, that over the northern parts of this country, this body of water must have stood at least 2000 feet above the present sea level; and I might safely put it at 2500 feet; for up to that height I have found drift modified by water."

9. As a consequence of these conclusions, it is argued that the drift period was a period of submergence for the larger part of the continent, and perhaps nearly the whole, and since that period, the ocean has stood 2000 feet deep over New England.

10. The formation of the succession of beaches might have taken place by a gradual elevation and drainage of the continent, without pauses in the movement of elevation; yet it is possible that some such pauses may have taken place. Still, the author argues against the probability of such pauses, and finally against the possibility of pauses for river terraces in general, on the ground mainly of their unequal heights on opposite sides of the streams.

11. As regards North America, "we may as yet safely say, that there is no evidence of the existence of life in the seas that covered it during the period of unmodified drift; and indeed we might say the same of a considerable part of the period of the modified drift and alluvium."

12. Glaciers probably existed on the mountain summits that stood above the waters, as facts appear to show.

13. The apparent elevation of the continent may have been a consequence of an actual sinking of the bed of the ocean drawing away the waters from the land.*

14. The drift scratches and transportations of stone, gravel, etc., were produced mainly by icebergs during a period of continental submergence.

* It is stated here that Professor Dana has sustained this view. But in his paper on Terraces, he only suggests it as a point to be considered in the study of terraces and not as an opinion he held. He has often urged that any change of elevation in the water-line of a coast, may be a result of either one, or of both, of the two causes,—changes of level in the continental areas of the earth's crust or in its oceanic areas, the latter having nearly three times the surface of the former. He has treated the subject in a general way, and has stated that the *average* elevation of the land of the globe in the present epoch, above that in the Silurian may not be more than is a necessary result of the deepening of the ocean's bed. But he has no where attributed any particular case of apparent elevation to simply and solely the drawing away of the waters by a sinking of the ocean's bottom.

To appreciate the amount of evidence of various kinds urged in the memoir as well as the labor expended in the researches, recourse must be had to the original paper. The so-called beaches, at the various elevations, which with the drifted stones and scratches are regarded as the special proofs of the great submergences in the ocean, are described with care, and laid down on the charts.

The most important link in this evidence of submergence is still undiscovered. We know of many submergences in past time, for we have marine fossils in the strata; and when we come to the very latest of these continental submergences, we naturally enquire for those unmistakable sea-records, the marine shells. The coasts of various countries, to a great height, bear this decisive mark of elevations during the recent post-tertiary epoch,—Scandinavia, and other parts of Europe, Peru, Chili, Patagonia, Australia, etc. etc. And on this continent, fossiliferous beds assure us of an elevation of 500 feet or so along the St. Lawrence and Lake Champlain during the terrace period, and of still greater changes in the Arctic. We feel a degree of delight in such positive demonstration; there is actual exhilaration in the sight of such an accumulation of shells as occurs at Beauport (Canada). And at the same time we look upon an argument as to continental submergence with distrust when the sea-relics fail, especially if this failure is for the whole continent, an area of millions of square miles. It is fair to doubt, and disbelieve, until the sea-record in fossils somewhere comes to light; and it is reasonable to regard it as much against its ever appearing that the indefatigable researches of Prof. Hitchcock have not found it. As to the supposed absence of life in the seas during the post-tertiary, can it be believed, when 25 to 40 per cent of the species of the preceding tertiary period are animals now living in our waters?

It is true, that if the supposed submergence had taken place, sea-shells are not to be looked for everywhere. In a river like the St. Lawrence, the water at Montreal is essentially on a level with the ocean, the elevation being but 21 feet, and not exceeding what is made by the flow of the water. Now notwithstanding this one level for the whole, the salt water—salt *enough to grow marine shells*—sets back in this great stream but a small part of this distance; and consequently while there are deposits with marine shells along the gulf, there are alluvial deposits without marine shells over the banks for 300 miles below Montreal. Now, when the sea stood 500 feet above its present water line, in the St. Lawrence, the pure salt water set back to Montreal and even as far as Ogdensburg, and also up Lake Champlain, where in either region it had its marine shells in profusion. But beyond this to the westward, the stream would, from some point, owing to the descending floods of fresh-water, be fresh, although on a level with the sea; and thus its shore flats—afterwards to become terraces—would have had no salt-water shells. Thus there might be true lake terraces and marine terraces made on the borders of the same waters, and all at the same level. In the Connecticut and Hudson rivers, again, sea-shells hardly enter the mouth. The lesson we learn is this: that in no case could we expect to find marine fossils in river terraces except where those rivers opened into wide estuaries;—and also, wherever wide estuaries existed, or where there was a shallow muddy sea-bottom off an existing coast, deposits of shells like those of the St. Lawrence and Lake

Champlain are to be looked for; and at least, in every thousand miles of such sea coast, some estuary or shore deposits might be reasonably expected.

While therefore, this important kind of evidence is wanting over this continent; and while it is not shown that icebergs could make the scorings of the rocks; and while it is not clear that a submergence of the northern part of North America could be a period of *unusual* glacier cold for the world when the effect of submerging northern lands it is known would mitigate cold, we have some reason for doubting the supposed submergence of the continent in the drift period.

This subject should be considered from every point of view. While constrained to differ in some few points from the memoir of Prof. Hitchcock we commend it as abounding in valuable observations. J. D. D.

3. *Outlines of the Continents.*—At the meeting of the American Association at Montreal, Prof. Peirce pointed out a relation between the direction of the coast-lines of the continents and the Arctic and Antarctic circles. The coast-lines, according to the view, lie in great circles that are tangents to these polar circles. Consequently if either pole of a terrestrial globe be elevated 23° 28′ so that the horizon becomes such a tangent great circle, and then the globe be slowly revolved, these coast-lines, as they pass the horizon circle, will be found approximately to coincide with it in direction. Elevating the north pole, and revolving in one direction, eastern North America makes this coincidence, and in the other direction western North America; and so for other great outlines of the land. He regarded this remarkable relation (23° 28′ being the obliquity of the ecliptic) as evidence that the sun by influencing in some way the cooling of the crust, had determined the grand outlines of the globe. We wait for a full announcement of his views before giving further details.

These facts had been announced in Boston journals a few months previous. Shortly after their first appearance in print, the work of Professor R. Owen of Kentucky, entitled "Key to the Geology of the Globe," was published in New York City—a work noticed in the number of this Journal for last July (this volume, p. 158); and it contains on page 36 a mention of the same relation and a similar elucidation by reference to a globe. Prof. Peirce alluded to this in conversation with us at Montreal. In the use of the observation the views of this work diverge from those of Prof. Peirce.

4. *Third Annual Report on the Geological Survey of the State of New Jersey for the year* 1856. 80 pp., 8vo. Trenton, 1857.—The first 38 pages of this pamphlet are occupied by the report of the geologist, William Kitchell, the next 30 with the report for the year on the geological survey of the southern division of the State by George H. Cook, Assistant State Geologist, and the remainder by a brief report of the State Topographical Engineer, E. L. Viele. The magnetic iron ores and iron furnaces of New Jersey are the subject of the first part of the volume, and many facts are brought out of practical value to the state. Prof. Cook, besides other results of importance, gives several analyses of the greensand and marls of New Jersey, which we propose to cite in a future number of this Journal.

The people of New Jersey have much to gain from the prosecution of the geological survey which has been begun, and we trust that it will not fail of the requisite support.

5. *Microgeology of Ehrenberg.*—A continuation of Ehrenberg's great work has been recently issued, consisting of 88 pages large folio; and it relates exclusively to North America. It consists of descriptions of earths and river sediments, from the different states of the country, as regards their infusorial contents, and tables of the results for each. The parcels examined and here described amount to 247, 85 of which are from Texas, 4 from Arkansas, 36 from the Washita and Neosho, etc. The number of microscopic species observed by Ehrenberg and Bailey in the Southern United States is 855; of these 148 are brackish water and marine species, about half of them being fossil and half living.

6. *Note on New Fossils in the Potsdam Sandstone at Keeseville, New York;* by J. D. Dana.—Hitherto the Potsdam Sandstone of New York, the lowest rock of the Silurian, has been known to afford no fossils but one or two species of the genus Lingula. Through the researches of a young and energetic student in geology, of New Haven, Mr. Frank H. Bradley, who visited Keeseville last summer and has recently been again at the locality, a species of Trilobite (genus *Calymene*) has been discovered, and also one of *Pleurotomaria*, besides an impression of a crinoidal disk. The Pleurotomaria is only a cast. The Trilobite, although a small one, its breadth but one-eighth of an inch, is well preserved. The buckler and caudal extremity have not been found together, but the markings of each are very distinct.—*Proceedings Montreal Meeting Amer. Assoc.*

## III. BOTANY AND ZOOLOGY.

1. *An Elementary Course of Botany; Structural, Physiological, and Systematic; with a brief Outline of the Geographical and Geological Distribution of Plants.* By Arthur Henfrey, F.R.S., L.S., &c., Professor of Botany in King's College, London, etc. 1857, pp. 702, small 12mo. London, Van Voorst.—This is a well-planned, compact, and comprehensive work, in which we may say, that the author has fairly accomplished his purpose, namely :—"to produce a good working text-book for the student, from which may be obtained a groundwork of knowledge in all branches of the science, without the attention being diverted from the more striking features of the subject by details comparatively unimportant."

The work is divided into four parts: I. Morphology or Comparative Anatomy, treating, in successive chapters, 1st. of General Morphology; 2nd, of the Morphology of the Phanerogamia, or the parts of Flowering plants and their modifications, and the laws which regulate them; 3d, Morphology of the Cryptogamia. Part II. Systematic Botany; treating 1st, of the principles of Classification; 2nd, of systems of Classification, and 3d, systematic descriptions of the Natural Orders, followed by an artificial analysis. Part III. Physiology; comprising, 1st, the physiological anatomy of plants; 2d, general considerations on the physiology of plants; 3d, physiology of vegetation; 4th, the reproduction of plants; 5th, Miscellaneous phenomena, under which are ranked the evolution of heat in plants, luminosity, and movements of plants. Part IV. Geographical and Geological Botany, very summarily disposed of in about forty pages.

It seems strange at first to interpose Systematic Botany between the morphological and the physiological; but if the anatomy and physiology of plants are to be completely disjoined from the study of the organs of the plant as a whole, the present arrangement is perhaps as good as any. It is adopted, as the preface shows, for the convenience of instructing medical students, who compose the principal part of classes in Great Britain as well as on the Continent;—for whom "one short course of lectures is devoted to this science, and three months is commonly all the time allotted to the teacher for laying the foundations and building the superstructure of a knowledge of botany in the minds of his pupils, very few of whom come prepared even with the most rudimentary acquaintance with the science." But the author remarks that "if the previous education of medical students prepared them, as it should, with an elementary knowledge of the natural sciences, we should make physiology the most conspicuous feature of a course of botany in a medical school."

While in England botany is scarcely an academical study, here it pertains to collegiate and academical instruction where it is taught at all. In Europe not even an apothecary can be licensed without passing an examination in botany; in the whole United States, we believe, it forms no part, at least no regular part, of the medical curriculum; no medical school has a botanical chair; and no knowledge whatever of the science of the vegetable kingdom, which supplies the greater part of the *materia medica*, is required for the degree of Doctor in Medicine!

Professor Henfrey is chiefly known, and most highly esteemed, as a vegetable anatomist. Upon this subject he may speak with an authority which, as a systematist, or even as a morphologist, he would not pretend to. We shall offer no apology, therefore, for making an occasional criticism, and for pointing out several errors in matters of detail. These are not intended to disparage the work, for if we had not formed a high opinion of it on the whole, we should not take this trouble.

As respects the first point noticed, our author, if wrong, is not alone. Still, we hardly expected him to teach that the radicle of the embryo is the true root; and we cannot let pass unchallenged his reiterated statement that in Monocotyledons, the radicle, or its inferior extremity, is never developed into a root in germination, but is abortive (pp. 14, 16, 18, 391, 537). Any one who will examine the germination of the seed of an Iris, an Onion, or even of a grain of Indian corn, cannot fail to perceive that a primary root is developed, and that this is a direct prolongation of the extremity of the radicle. This, indeed, does not continue as a tap-root; neither does it in a great many Dicotyledons. In squashes, pumpkins, &c., there is no one primary root, but a cluster of rootlets from the first, all springing from the base of the stout radicle. In fact, this distinction between Monocotyledons and Dicotyledons is null. A character of certain monocotyledonous embryos, neither strictly peculiar to the class, nor by any means universal in it, should not be assumed as distinctive. As to the morphology of the radicle *itself*, we suppose that the germination of any of the larger Cucurbitaceæ, or of a bean, would suffice to convince any observer that the radicle is simply the first internode of the stem, giving birth to the primary root from its inferior extremity, usually,—and indeed, from the exceptional cases where it does not we should draw addi-

tional proof of its cauline nature. In fact, we know of no character in which a root differs from an internode of a stem in which it does not also differ from the radicle, excepting its tendency to direct its inferior extremity downwards. Again, should the statement, that "the radicle of a monocotyledonous embryo is never developed" be held to mean that the radicle never lengthens, we remark, no more does it in the pea and some other hypogæous Dicotyledons; and we are not quite sure that the statement is absolutely true of all Monocotyledons.

Root-hairs or *fibrillæ* are mentioned (p. 19) as "often" occurring on young roots. Do they not *always* occur? Surely it cannot be true that: "the branches of the axial root are originally growths from the apex of the root thrown off to the side," (p. 538). By some slip of the pen, *Myrica Gale*, is adduced as an instance of whorled leaves (p. 45).

On p. 49 the expression "*over* the petiole" instead of *above* or within it, would lead to a misconception.

Something more might be said about the tendrils of Cucurbitaceæ (which besides are not always single); but are the students of King's College really taught that, "tendrils of the vine are metamorphosed flowering branches *arising in the axils of the leaves?*" (p. 62.)

"In all seeds except in those of the few orders which present an incomplete or acotyledonous embryo" we do *not* find the young plant possessed * * of a plumule" (p. 66). Even some much developed embryos, such as those of Maple and Morning Glory do not show the plumule until after the full development of the cotyledons. It may be said, indeed, that the plumule is *in posse* when not *in esse*, but so it is no less in the cases excepted from the statement.

Very singular is the statement (on p. 68) that in England "the terminal bud of the Lilac is generally killed by the frost in the winter;" since in our much colder winter it is as completely hardy as the other buds whenever it happens to be formed, and, like them, is well developed before summer is over. As a general rule here, and we presume in England also, no terminal winter bud appears during the growing season, and so there is none to be killed by the frost of the following winter.

The deeply alveolate receptacle of the Cotton-Thistle is figured (on p. 78) as an illustration of a *paleaceous* receptacle.

Truly *terminal* flowers are said to be rare (p. 86): we do not quite understand this.

The interesting questions relating to the phyllotaxy and symmetry of the flower are clearly stated, but no new light is brought to bear upon them,—nor all of the old. The opposition of the stamens of Rhamnaceæ to the petals is, as usual, attributed to the probable suppression of an outer stamineal circle, although there is nothing in the blossom (as there is in Geraniaceæ, &c.) to base the supposition upon. And our author has overlooked the most natural of explanations for this and strictly like cases, the one moreover which tells directly against the doctrine of transverse chorisis.—viz., that in these cases of *ante-position* there is a return to normal phyllotaxy, i. e. to the superposition of the corresponding elements of successive whorls,—a view first suggested, we believe, by Lestibudois.

"Real cases of *collateral* multiplication may probably be explained by comparison of a primary staminal leaf with an ordinary compound stem-

leaf, and supposing the filament to subdivide like the petiole does [sic] in such cases." This is certainly the way we regard it; and as respects the application of this hypothesis to the stamens of Cruciferæ, we do not see what argument *Megacarpæa polyandra* brings against it; as the increase in the number of stamens is quite as explicable upon this as upon the ordinary theory. Indeed our author's view that the glands represent suppressed stamens would seem to be negatived by this very case, since the glands have not disappeared with the increase of the stamens, but the contrary.

The abnormal fertile flowers of *Viola* and *Impatiens* are not "achlamydeous," as our author states them to be (p. 90): generally they are not even apetalous.

In the botanical sense of the word, and as it is employed in the same sentence (p. 93) the petals of the vine cannot be said "to cohere above." The valvate petals are merely caducous for the most part before expanding, just as is more decidedly the case in many Araliaceæ. In passing, we remark that a valvate æstivation of the corolla in the latter is much less distinctive than our author supposes (p. 311). *Aralia* itself has the petals imbricated in the bud.

It is becoming common to regard the tube of a so-called *superior* calyx as a cup-like receptacle; and there appears to be reason for it in Cactaceæ and some other cases. Prof. Henfrey would seem to apply this view universally; "for example, in Rosaceæ, Umbelliferæ, Cucurbitaceæ, Compositæ" [!] &c. But if applied to *Rosa*, why not to the Sanguisorbeæ and to other Rosaceæ with a calyx-tube lined with a disk bearing the stamens, &c.? And is the cup a receptacle in those Melastomaceæ which have an adnate ovary, but a calyx when the ovary is free? And how is it when the ovary and cup cohere only by the nerves of the latter?

For *paleæ* Prof. Henfrey coins an English word *pales* (p. 110), of which the singular would probably be *pale*. We would propose to call them *palets*.

There are convincing reasons why the perigynium of Carex cannot be regarded as a perianth, as our author takes it to be (p. 111).

It is not correct to say that the false dissepiments of Datura are formed "while the seeds are ripening" (p. 124); they equally exist in the ovary. And we doubt if the transverse false septa in *Cathartocarpus* and other Leguminosæ are "placental developments."

We are pleased to find that our author prefers to consider placentæ as belonging to the carpels rather than to the axis, although the close of paragraph 226 appears to imply the contrary.

We cannot agree that, "externally the campylotropous ovule resembles the anatropous, except that there is no rhaphe," (p. 130). No attentive student could fail to recognize the difference, especially in the families cited (Cruciferæ and Caryophyllaceæ).

Ripening must be regarded in a remarkably broad sense when it is stated with emphasis, "that the distinction between endocarps and epicarps, in the common stone-fruits, arises entirely during the ripening of fruit." Also: "it is well known that the easy separation of the pulp from the stone is a sign of ripeness." When are cling-stone peaches ripe? Again: "In Taxus * * during the *ripening* of the seed a succu-

lent cup-like envelope grows up around it" (p. 136). Is ripening synonymous with the formation and growth, as well as the maturing of the fruit?

Lindley's system of the classification and nomenclature of fruits is adopted, with some modifications. It is well to have such a system, as an analysis of the diversities of structure; but of the thirty-six kinds so carefully defined and named only fifteen or sixteen are ever used in descriptive botany, or ever will be, it is devoutly hoped. There is much inconvenience in practice, and little advantage in designating every possible modification of the same organ or set of organs by a distinct substantive name, or in distinguishing by separate technical names fruits formed of a simple ovary from those of a compound ovary, or fruits with an adherent from those with a free ovary. Why not call the gooseberry and the grape equally a berry, instead of restricting this name to the former and naming the latter a *nuculanium;* and why name the pod of an Iris a *diplotegia*, while that of a Lily is called a *capsule?* And while we term the pod of *Saxifraga stellaris* a *capsule*, and that of *S. tridactylites* a *diplotegia*, what name are we to apply to that of *S. aizoides*, which is only half-superior?

Probably a wrong example is adduced on p. 148, for we cannot believe that any species of Ranunculus has the rhaphe averse from the placenta in the ripe fruit. By an oversight, on the same page, the fruits of Labiatæ are spoken of as seeds.

As respects the systematic part, the chapters on the principles of classification, nomenclature, &c., strike us as sound and good throughout; and in the account of the natural orders a great amount of information, such as the medical student needs, is given in a comparatively small space. Errors or misconceptions will necessarily occur in the compilation of such an amount of materials, treating of structure, affinities, distribution, sensible properties and medicinal or economical uses. They are not more numerous than was to be expected, and we are not disposed to make them the subject of criticism.

We may remark, in passing, that, as respects the morphology of the androecium in Fumariaceæ, the name of the writer of the present notice is referred to, by some misconception, as adopting Lindley's well-known hypothesis of the splitting of two stamens into halves; whereas he has maintained a very different view. And then this is mentioned as "offering a phenomenon of chorisis," which in that view is quite incomprehensible to us.

We were surprised at the statement that the bark and leaves of *Hamamelis Virginica* "are astringent and contain an *acrid volatile oil*," p. 307. We trace it back to Lindley's *Vegetable kingdom*, p. 784, and find: "The kernels of *Hamamelis Virginica* are oily and eatable. The leaves and bark are very astringent, and also contain a peculiar acrid essential oil;" and this, we find, comes from Endlicher's *Enchiridion*. How did this bland and inert plant acquire such a reputation? Dr. Barton, who has figured it, says nothing of its possessing any sensible properties or useful qualities at all, except its use for divining-rods; nor do Pursh, Bigelow, Elliott, Darlington, &c., allude to any popular reputation of such qualities. No sign of any essential oil is to be detected in the foliage, and prolonged

mastication of the leaves and bark while we write yields not the slightest trace of acridity and hardly any of astringency; no more, certainly, than a Beech-leaf. We never heard of the seeds being eaten; and as they are "about the size of a grain of barley," or not much larger, and have a thick bony coat, they are not likely to become an important article of diet. After some search, we find the source of these extraordinary statements in the *Medical Flora* of the excentric Rafinesque. He says the seeds are called Pistachio nuts in the Southern States, are rather oily and palatable, &c., but he neglects to mention their size. He adds, "the bark and leaves are somewhat bitter, very astringent, leaving a sweetish pungent taste. The smell is not unpleasant. It has not been analyzed as yet, but probably contains tannin, amarine, extractive, and an essential oil." To all this, Endlicher, on the strength of "the sweetish pungent taste," has added the acridity; and so one of the blandest and most useless of shrubs gets a world-wide and wholly factitious reputation for active medical qualities and esculent seeds; and even Dr. Griffith, who must have known the shrub, has been induced to give it a place in his Medical Botany.

Our remaining remark relates to the random way in which mere analogies are mixed up with affinities in estimating or expressing the relationship of orders, &c., in this as in some other more notable works. It is, or at least ought to be, well understood, that mere *analogy*, i. e., likeness in some one respect only, however striking the imitation, is no indication of relationship, but that relationship rests upon *affinity*, i. e., upon agreement or similarity in the whole plan of structure, and especially of floral structure, whether general or particular, as the case may be. To speak, therefore, of 'evident' and 'most distinct' affinities between *Coniferæ* and *Lycopodiaceæ* is an example of this prevalent misconception of what affinity is. This is more intelligible, however, than the 'approach' suggested of *Aquifoliaceæ* to *Loganiaceæ* and *Apocynaceæ*, while their resemblance to *Celastraceæ* is thought to be of small account; or that of *Umbelliferæ* to *Rubiaceæ*, *Saxifragaceæ*, and even to *Geraniaceæ*, to which the resemblances do indeed "seem rather superficial." Again, *Xanthoxylaceæ* (i. e. *Rutaceæ*) are said to have considerable affinity to *Oleaceæ*, because *Ptelea*, in the former, has a samaroid fruit, as has *Fraxinus* in the latter. May we add, as quite as much to the purpose, that the common Xanthoxylums have pinnate leaves, and are popularly called Prickly Ash?

The study of affinities is neither guess-work nor divination, but a matter of logical deduction from structure, based upon scientific principles,—principles recognized and acted upon by sound botanists with considerable unanimity, although they have never been reduced to a system, nor expounded in detail, so as to make them matters of elementary instruction. Until this desideratum is supplied, the young botanist can do no better than to take as models the writings of Brown, and of those botanists who, according to their ability, have most closely followed the footsteps of this master in science.

Having continued this review far beyond our intention at the outset, we have small space left for noticing the best part of Prof. Henfrey's treatise, namely, the third or Physiological part. Suffice it to say that, in the important chapter on the physiological anatomy of plants, our author writes

from the fullness of his acquaintance with the writings and doings of all the continental phytotomists, and also with the authority of an experienced original investigator. And, so far as we know, it comprises much the best *resumé* of vegetable anatomy and development now extant in the English language, at once succinct, clear, trustworthy, and well brought up to the present state of the science. Perhaps the succeeding chapters, on the Physiology of Plants generally, the Physiology of Vegetation, and on Reproduction, are equally commendable in their way; but we have as yet barely glanced over the pages. We like the following definition, and the ensuing paragraph upon the *rôle* of vitality in plants.

"The physiology of plants is that department of botany in which we investigate the phenomena of the *life* of plants, manifested in a series of changes taking place in the diverse parts of which each plant is composed."—p. 475.

"The physiological phenomena which indicate vitality are always of more or less complex nature, and admit of being analyzed into a number of factors, of which a large proportion are found to be purely physical or chemical. A very considerable part of the changes which accompany the process of organization are the results of the action of physical and chemical forces, [and] capable of being explained up to a certain point, by the known laws of those forces. But in every case, after referring all the chemical and physical phenomena to their respective places, there remains a residual phenomenon to be accounted for, which is precisely the most important of all,—namely, that in living organic structures . . . . the laws of inorganic matter are subdued under a higher influence, and caused to undergo modifications never occurring except in the presence of living matter; while—most important of all—the peculiar compounds of matter thus produced are not only made to assume forms, according to definite laws, totally unlike any forms of mineral matter, but [to] constitute bodies manifesting a continued interchange of material with the surrounding media, which, instead of resulting in decomposition, as in mineral bodies, effects a reproduction and increase of the already existing [organized] matter."—p. 542.

In the paragraph on the longevity of trees (p. 549), we find renewed occasion to notice the longevity of unfounded statements, copied from one book into another long after the error has been pointed out. Here again the *Adansonia* of Senegal and the *Wellingtonia* or *Sequoia* of California figure as trees "whose age, deduced from the rings of growth of the stems would amount to upwards of 3000 years." There is really no evidence to prove that the famous Baobabs described by Adanson are of such an age, and as to the *Wellingtonia* in question, an actual counting of the rings has shown that the tree was not half so old as it was vaguely computed to be.

The chapter on Reproduction appears to be excellent, as indeed we should expect. The geographical and geological part is necessarily very briefly treated. A. G.

2. *Naudin's Researches into the Specific Characters and the Varieties of the Genus Cucurbita*, are published in the 6th volume (4th series) of the *Annales des Sciences Naturelles*, and are of no small interest, being founded upon a very conscientious investigation of nearly all the known

forms, collected for the purpose, and cultivated under the author's eye at the *Jardin des Plantes*. These forms our author reduces to six species, and the alimentary sorts in cultivation, to three, viz. *Cucurbita maxima*, *C. Pepo*, and *C. moschata*. The remaining three species are *C. melanosperma* of Braun, newly introduced from Eastern Asia, and the two perennial and tuberous-rooted species, *C. perennis* and *C. digitata*, Gray, natives of our southwestern borders, the fruits of which are not esculent. Indeed the pumpkins and squashes cultivated in Northern Europe and with us, as now understood, belong to only two species, since the third, *C. moschata* hardly comes to perfection north of the Mediterranean region. Of these *C. maxima* is made to include *C. Melopepo;* and *C. Pepo*, comprising our pumpkins and a large part of our squashes, is made to include *C. ovifera*, *aurantia*, *verrucosa*, &c., and the species are defined by botanical characters, which apparently may be relied upon. The varieties of *C. maxima* fall into two main groups, characterized by their fruits, viz., the *Turbans*, having *crowned fruits*, that is, the summit projecting beyond the adnate calyx-tube, a peculiarity found in no other species, and the *crownless* sorts, in which this peculiarity is not manifest. The innumerable varieties of *C. Pepo* are arranged in seven groups, according to the configuration of their fruits.

M. Naudin has not undertaken to discuss the questions respecting the birth-place of these plants. He remarks that *C. maxima* and *C. moschata* have been known in European gardens scarcely above two centuries; but that *C. Pepo* was perhaps known to the Greeks and the Romans in the time of Pliny.

The younger DeCandolle, in his discussion of the history and origin of the principal cultivated plants, which form a most interesting chapter of his *Géographie Botanique*, although he is unable to assign them to any country as their home, confidently (perhaps too confidently) refers all the squashes and pumpkins to the Old World; but not to India, because they have no Sanscrit name. He will not believe that any of them came from America, and appears to think little of the current statements that squashes or pumpkins were in cultivation by our aborigines before the European settlement of the country. On the other hand, our lamented Dr. Harris, —who, during the later years of his life, assiduously studied this question, and who was very cautious in drawing conclusions,—had become satisfied that the North American Indians as far north even as to Canada, cultivated squashes and pumpkins, one or both, along with their maize, before the whites were established here. We are unable at this moment to refer to his manuscripts, or to what he had too imperfectly published upon this subject. But we well remember his laying much stress upon the narrative of Champlain; and with good reason, as it appears to us on turning casually to the pages of *Les Voyages du Sieur de Champlain .... ou Journal tres-fidèle des Observations faites et Decouvertes de la Nouvelle France*, &c. &c., edition of Jean Berjon, Paris, 1613, 4to.: also *Voyages et decouvertes faites en la Nouvelle France depuis l'année* 1615, *jusques à la fin de l'année* 1618,—second edition, published by Collet, in 1627, small 12mo,—to which volumes we desire to direct M. DeCandolle's attention. In Champlain's narrative of his own voyage along the coast of what is now the State of Maine, in the year 1604, and the two voyages

of Le Sieur de Mons along the coast of New England in 1605 and 1606, *Citrouilles* and *Courges* are repeatedly mentioned, along with maize (*Bled d'Inde*) and beans: e. g.

"Nous y vismes force *citrouilles*, *courges* & petum, qu'ils cultiuet aussi. . . . Pour les febues elles cōmēçoiēt à entrer en fleur, cōme faysoyēt les courges et citrouilles."—p. 68.

"Ceux que nous auions enuoyes deuers eux, nous apporterent des petites citrouilles de la grosseur du poing, que nous mangeasmes en sallade comme coucombres, qui sont tresbonnes."—p. 77.

See also pp. 83, 115, 116. Of course it does not follow that these esculents were natives of New England, any more than maize: but both may probably have been carried northward together. Whatever their origin, our Indians were found cultivating them together at this early date as well as in later times. According to Nuttall the Indians along the whole Upper Missouri half a century ago were cultivating *Cucurbita verrucosa*. This common squash is, according to Naudin, a variety of *C. Pepo*, as also is *C. aurantia* (the *C. Texana* vel *ovifera*, Gray, Pl. Lindh.) which has every appearance of being indigenous in the western part of Texas, on the Rio Colorado and its upper tributaries. At least, this is the opinion of Mr. Lindheimer and of Mr. Charles Wright, two good judges. The latter personally informs us that, from the stations and localities in which alone it is met with, he could not suspect it to be other than an indigenous plant.

That the later Greeks and Romans possessed the bottle gourd or *Lagenaria*, and also some kind of summer squash, seems pretty clear; but we see no decisive reason for the opinion that they had any form of *Cucurbita Pepo*, as that species is now understood. According to DeCandolle, the earliest figures referable to this species are, one of *C. ovifera* by Lobel in 1576, and one of *C. verrucosa* by Dalechamp in 1587, namely, about a century after the discovery of America, and long after maize had become well known in the south of Europe: and we have seen that some forms probably of this very species (undoubtedly originating in a warmer region) had by this time found their way in this country nearly as far north as the climate will permit of their cultivation. So that there appears to be about the same evidence for the American origin of *some* squashes and of pumpkins that there is for the American origin of maize.

A remaining argument brought by DeCandolle against this view may also be turned the other way, namely, that no certain species of the genus is known as indigenous to America. He has equally allowed that none is known to be indigenous to the Old World. Now of the six species recognized by Naudin, two only are known in their natural wild state, and these are our southwestern species with perennial roots, viz., *C. perennis* and *C. digitata;* to which we add that *C. Pepo* itself (i. e. *C. ovifera* or *aurantia*) grows wild in the same district with *C. perennis*, and has the same appearance of being indigenous there. We leave the subject with these incidental remarks, as we did not intend here to investigate this question, and will briefly allude to another subject, upon which Naudin's investigations have thrown new light.

It is generally thought that the cultivated *Cucurbitaceæ*, and especially that the species of *Cucurbita*, cross-breed with extreme facility. Accord-

ing to Naudin this is true of the *races* only *inter se.* A good illustration of the immediate and great variation from this cause in the fruit of *C. Pepo* is given in Naudin's third plate, where fifteen different forms of the fruit are figured, taken from as many individual plants raised from seeds of one fruit, which had grown in the vicinity of other varieties. It is by no means certain, however, that all these forms originated from direct crossing. But the species themselves strangely refuse to hybridize. Naudin carefully experimented with the five species in cultivation at the *Jardin des Plantes* (viz., all known, except *C. digitata*): and out of seventy distinct trials all but five were utterly ineffectual. In five instances the fruit set, indeed, but in none of these was a single seed containing the vestige of an embryo produced! What are we to think, then, of the universal belief that squashes are spoiled by pumpkins grown in their vicinity, or pumpkins by squashes; and even melons (which are of a different genus) by squashes? The fact of some such influence seems to be well authenticated. Dr. Darlington, one of the most trustworthy of observers, speaks of it from his own knowledge, thus:—"When growing in the vicinity of squashes the fruit [of the pumpkin] is liable to be converted into a kind of hybrid, of little or no value. I have had a crop of pumpkins totally spoiled by that cause, the fruit becoming very hard and warty, unfit for the table and unsafe to give to cattle."—(*Fl. Cestr.*, ed. 2, p. 555.)

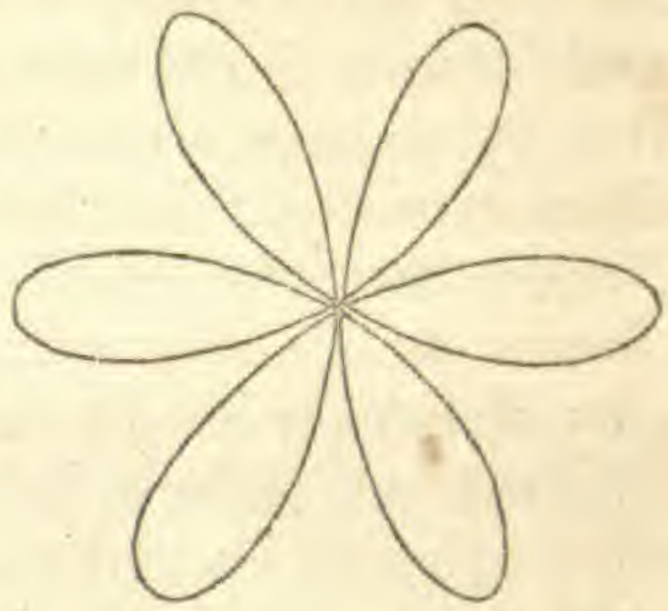
Now that this is not the effect of hybridation is clear from the fact that the result appears in the fruit of the season, not in that of the next year, viz., in a generation originated by the crossing. A clue is perhaps furnished by Naudin's observations, that the ovary is apt to set and even develop into a fruit in consequence of the application of the pollen of another species, although, as the result proves, none of the ovules are fertilized. And he hazards the conjecture that the pollen may exert a specific influence first upon the ovary, inciting its farther development, and then upon the ovules. To test this conjecture he was to examine the action, if any there be, of the pollen of *Cucurbita* upon the ovary of melons. The past summer,—which has been as unusually warm in Western Europe as it has been cool in this country,—must have favored such researches in Paris; and we may expect soon to hear of the result. Improbable as such an influence seems to be, it is hardly more so than the now authenticated fact that the graft of a variegated variety of a shrub or tree will slowly infect the stock, so that the variegation will at length break out in the foliage of the natural branches;—an old observation, which, according to the Gardener's Chronicle, has recently been verified in several instances. A. G.

## IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

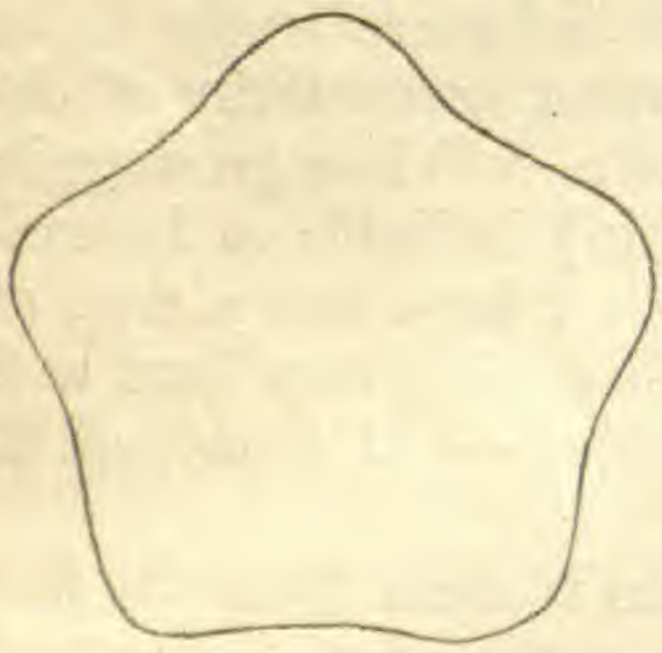
1. *Studies in Organic Morphology;* an Abstract of Lectures delivered before the Pottsville Scientific Association in 1855 and 1856, containing historical notes of this branch of science, together with original formulæ and constructions of curved lines, designed to assist in the imitation of organic forms; by JOHN WARREN. 58 pp. 8vo. Philadelphia, 1857.

J. B. Lippincott & Co.—This pamphlet relates to a branch of mathematics upon which little has hitherto been published in this country, and although the views are not new in principle, they are in part the result of original research by the author and new in some of their applications. The subject is the method of constructing curves of complex but regular figures similar to those in the Plant and Animal Kingdoms. The plates of numerous figures at the close of the pamphlet are instructive even to one who is not familiar with the use of the formulas on which they are constructed. The following are a few examples, from the 100 figures given.

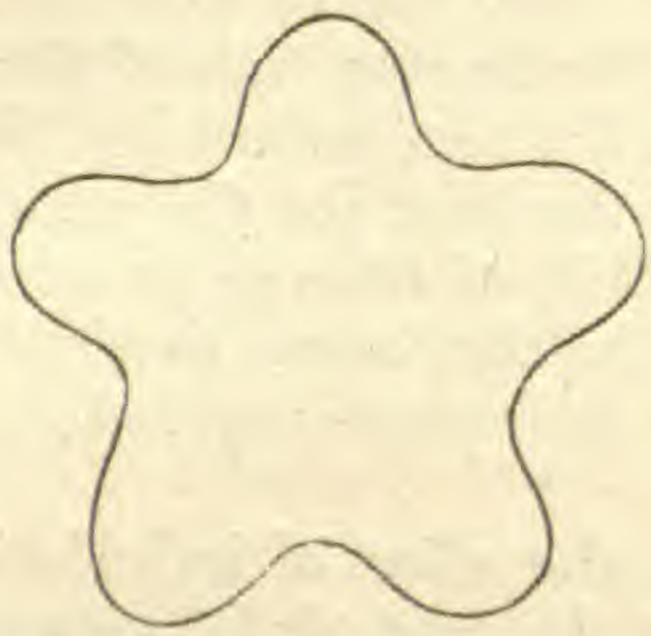
1.



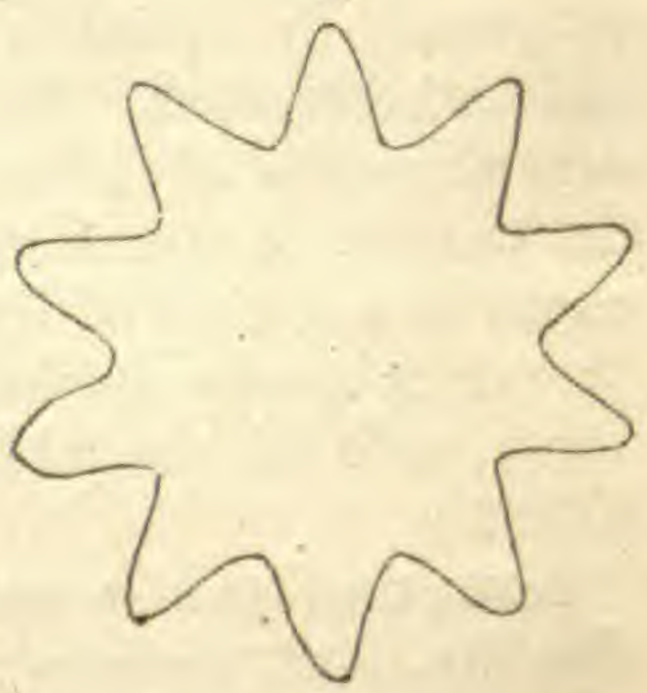
2.



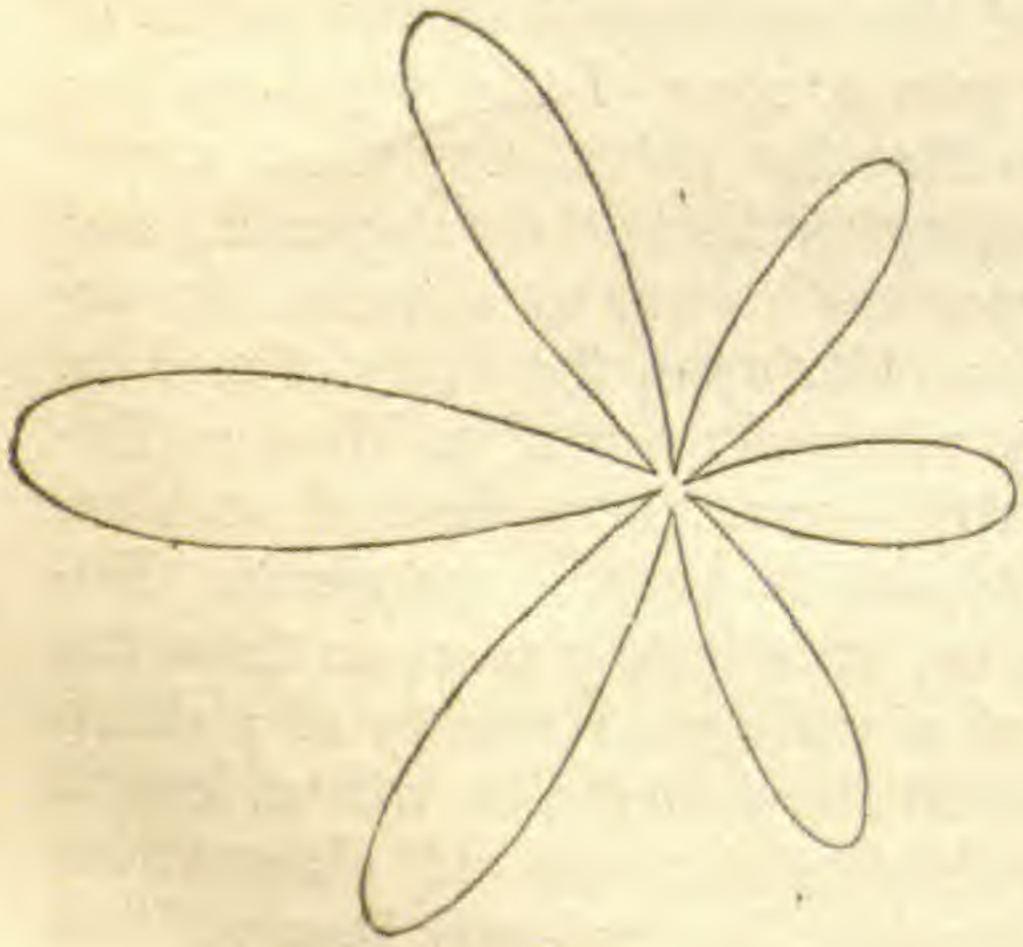
3.



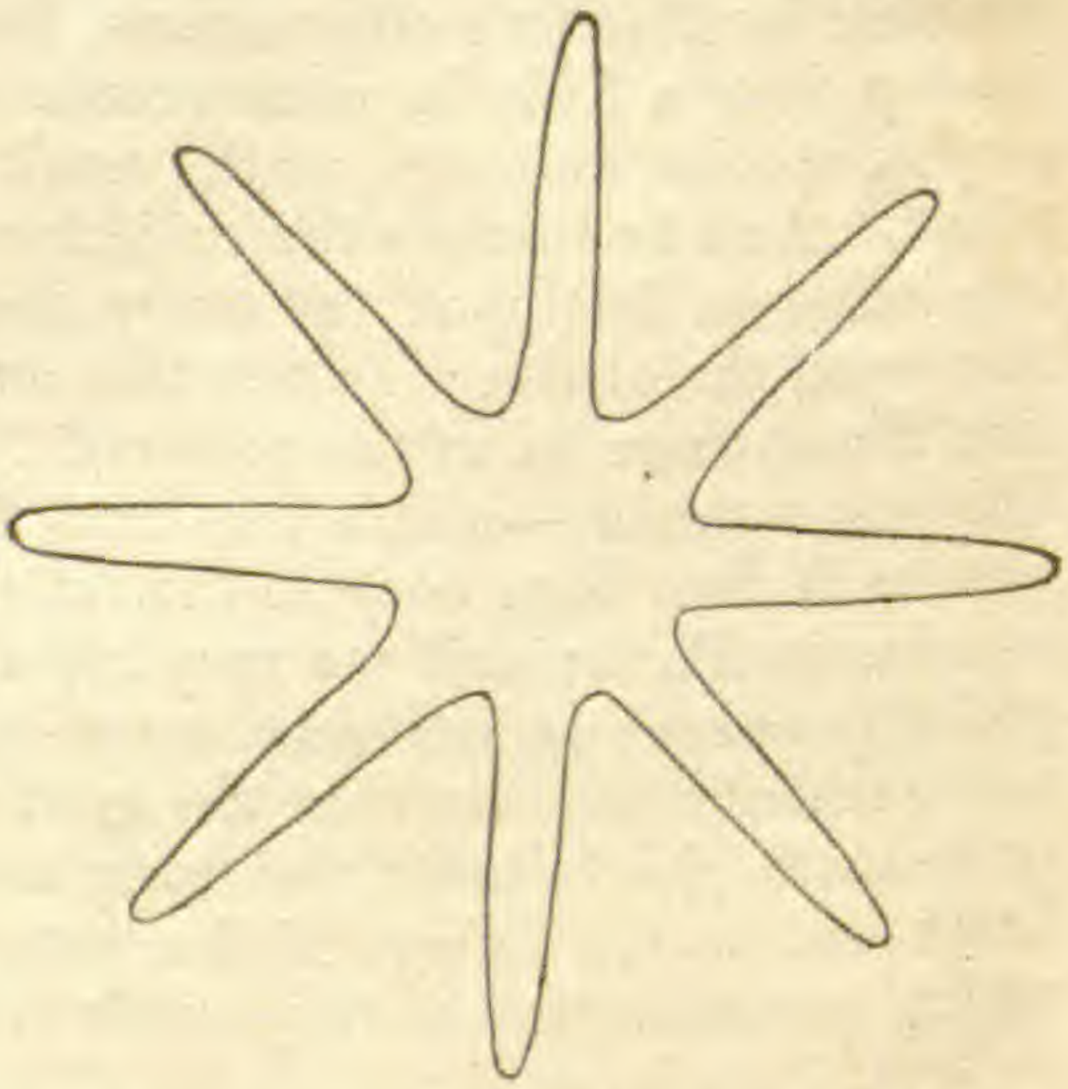
4.



5.



6.



The equations for these curves are as follows. 1. $\varrho = \pm m \cos 3\theta$, (from the paper published in 1723 by Dr. Grandus, entitled "A Collection of Geometrical Flowers," Abr. Phil. Trans. vi, 67.) 2. $\varrho = \dfrac{4{\cdot}5}{1 + {\cdot}1 \cos 5\theta}$.

3. $\varrho = 4 + \cos 5\theta$. 4. $\varrho = 4 + \cos 10\theta$. 5. $\varrho = \dfrac{3\,65 + 3{\cdot}55 \cos 5\theta}{1 + {\cdot}3 \cos \theta}$.

6. $\varrho = \dfrac{3{\cdot}2}{1 + {\cdot}6 \cos 8\theta}$.

2. *Gyroscope.*—Major Barnard will continue his discussion of the gyroscope in the January number of this Journal, and treat especially of "the motions of the gyroscope as modified by the retarding forces of friction and resistance of the air,"—explaining the discrepancies between the theoretical motion of a "solid of revolution" without friction or other retarding influences and the observed motions of the experimental gyroscope.

3. *Rapidity of thought or nervous action;* by M. Ule, (Revue Suisse, March 15, 1857). The method of transforming the valuation of time into space by the rapid revolution of a cylinder, proposed by Mr. Fizeau, has been applied to the measurement of the rapidity of nervous impulse. Such a cylinder rotating 1000 times a second, and divided into 360 degrees, may measure 1–360,000th part of a second; or rotating 1500 times a second, 1–540,000th part of a second; and even this may be subdivided by a microscope, so as to obtain the 10-millionth or perhaps 100-millionth part of a second. By this extreme minuteness of subdivision of time, it is not difficult to measure even the rapidity of a nervous impulse. If an electric shock be given to the arm, it produces a sensation, and a contraction of the muscles. Hence by noting the interval of time between the shock and the contraction, the time occupied by the transmission of the sensation and the action of the brain, however quick, will be determined. By trying the experiment with different parts of the body, sensible differences have been observed, the shock applied to the thumb being one-thirtieth of a second behind that applied to the face; and this difference pertains to the transmission and not to the action of the brain, and hence enables us to eliminate the latter in the experiments. In this way it has been found by M. Helmholtz, by whom these experiments have been made with the most care,

(1.) That sensations are transmitted to the brain at a rapidity of about 180 *feet per second*, or at one-fifth the rate of sound; and this is nearly the same in all individuals.

(2.) The brain requires *one-tenth of a second* to transmit its orders to the nerves which preside over voluntary motion; but this amount varies much in different individuals, and in the same individual at different times, according to the disposition or the condition at the time, and is more regular, the more sustained the attention.

(3.) The time required to transmit an order to the muscles by the motor nerves, is nearly the same as that required by the nerves of sensation to pass a sensation; moreover it passes nearly one-hundredth of a second before the muscles are put in motion.

(4.) The whole operation requires $1\frac{1}{4}$ to 2 tenths of a second.

Consequently when we speak of an active, ardent mind, or of one that is slow, cold or apathetic, it is not a mere figure of rhetoric.

4. *Smithsonian Contributions to Knowledge*, Vol. IX, 4to.—Contents.—L. W. Meech: On the relative Intensity of the Heat and Light of the Sun upon different latitudes of the earth. 58 pp., with 6 plates.

Edward Hitchcock: Illustrations of Surface Geology. 164 pp., with 12 plates.

Brantz Mayer: Observations on Mexican History and Archæology, with a special notice of Zapotec Remains as delineated in Mr. J. S. Sawkin's drawings of Mitla, etc. 36 pp., with 4 plates.

W. Gibbs and F. A. Genth: Researches upon the Ammonia-Cobalt bases. 72 pp.

*Appendix.* J. D. Runkle: New tables for determining the values of the coefficients in the perturbative functions of planetary motion, which depend upon the ratio of the mean distances. Also, Asteroid Supplement to new tables for determining the values of $b_s^{(i)}$ and its derivatives.

The appearance annually of one or more quarto volumes of papers containing the results of recent researches is abundant testimony to the productiveness of the Smithsonian fund. This is but one of the ways, it should be noted, in which the Institution is successfully laboring to increase and diffuse knowledge. In all, it is doing a great work for the country.

The first paper by Mr. Meech is a mathematical investigation of the varying amount of heat received by the earth from the sun arising from the variations in her phases of position and inclination. The topics of the chapters will give an idea of the mode of treating the subject. 1. Irradiated surface upon the planets. 2. The sun's intensity upon the planets, in relation to their orbits. 3. Law of the sun's intensity at any instant during the day. 4. The sun's diurnal intensity. 5. The sun's annual intensity. 6. Average annual intensity upon a part or the whole of the earth's surface. 7. Secular changes of intensity. 8. Local and climatic changes. 9. Duration of sunlight and twilight. Under the 7th head, Mr. Meech deduces, that taking into view the fact that the obliquity of the ecliptic, 2000 years ago, in the time of Hipparchus, 128 B. C., was 23° 43′, and now it is 23° 27½′, and that therefore the sun then rose higher in summer than now, the summer heat of that period was *two-tenths* of a degree Fahrenheit hotter than that of the present, while the winter was the same amount colder.

The article by Prof. Hitchcock has already been noticed (see page 430), and that by Gibbs and Genth has been republished entire in this Journal.

5. *A Monograph of the Tertiary Entomostraca of England and Ireland;* by T. Rupert Jones, F.G.S. London, 1856, 70 pages 4to, with 6 plates.—This work is one of the monographs published in elegant style by the Palæontographical Society of London, one of the most useful Scientific publishing Societies in the world. Mr. Jones has paid great attention to these minute Cypris-like species, and his works embrace a large part of what is known on these fossils. The Quarterly Journal of the Geological Society of London for November, 1856, contains another paper by Mr. Jones, on the *Estheria minuta*, a triassic species of the same group of Crustacea.

6. *Terrestrial Magnetism at Brussels and Paris;* M. Mahmoud, (Bull. Acad. Roy. Belgique, xxii, 14).—Inclination obtained with a Gambey needle in the garden of the Observatory, May 10–18, 1855, 67°42′·82 (mean of four determinations); absolute horizontal intensity, 1·8075; absolute total intensity, 4·7662. At Paris, March 4 and 5, inclination 66° 23′·18, absolute horizontal intensity 1·8817, absolute total intensity 4·6976.

7. *Fishes of China.*—Volume X, of the Nouveaux Mémoires de la Soc. Imp. des Naturalistes de Moscou, 1855, contains a paper on the Fishes of Northern China, by Dr. S. Basilewsky, with 9 quarto colored plates.

8. *United States Japan Expedition;* by Commodore M. C. PERRY, U.S.N. Vol. II, 420 pp., 4to, with many maps and plates.—The first and third volumes of the Reports upon this expedition appeared some time since, and now the second is added. It is devoted to the agriculture, mineral and other resources, natural history, geological characteristics, etc., of the places visited by the squadron, especially of Lewchew, Peel Island, Formosa, Japan and China. Although there was no naturalist on board the vessels, many valuable facts were collected. Under natural history, there is an important paper by Mr. JOHN CASSIN, of Philadelphia, on the birds of Japan, with colored plates; notes on some colored figures of Japan Fishes, by J. CARSON BREVOORT; a list of shells collected in Japan, with 5 plates, by JOHN C. JAY; Notes on the plants, by ASA GRAY; on the Ferns, by DANIEL C. EATON; exploration of Lewchew and other places, by Rev. GEORGE JONES.

9. *Fossils of South Carolina;* by M. TUOMEY and F. S. HOLMES. Nos. 11 and 12. Charleston, S. C., 1856. pp. 79–104, 4to, with 4 plates.—These numbers (in one) of this fine work continue the descriptions and plates of the South Carolina Pleiocene fossils, and include species of Venus, Petricola, Tellina, Psammocola, Lavignon, Sinodesmia, Amphidesma, Donax, Mactra, Gnathodon, Solecurtus, Panopœa, Pholadomya, Solen, and Pholas. The plates, as heretofore, are excellent, and the work should have a place in every geological library.

10. *Specimen Tables Calculated and Stereomoulded by the Swedish Calculating Machine.* xviii and 50 pp., large 8vo, with a plate of the machine. London, 1857. Longman, Brown, Green, Longmans & Roberts. —This calculating machine, by George and Edward Scheutz, is the most wonderful work of mechanical and mathematical skill combined which has been constructed. One of the specimen tables is a table of logarithms of numbers from 1 to 10,000, "calculated, steromoulded, and printed by machinery," a method which precludes error in the tables. It is stated moreover that "in the next machine, the rate of working may easily be increased ten-fold so that twenty pages may be quietly *calculated* and *stereomoulded* whilst a compositor was merely "setting up" a single page. Various other specimens of mathematical calculations are given.

11. *On Fichtelite, a fossil Hydro-carbon, found in the Fichtelgebirge of North Bavaria.* Inaugural dissertation, prepared for promotion to the degree of Doctor of Philosophy, and addressed to the Philosophical Faculty of the Georgia Augusta University at Goettingen, by T. EDWARDS CLARK, B.S., of Cambridge, Mass. 32 pp., 8vo. Heidelberg, 1857.—This memoir, which adds to our knowledge of the species Fichtelite, both as to its crystallization and composition, we propose to cite from at another time.

12. *Astronomical observations, made under the direction of* M. F. MAURY, Lieut. U. S. Navy, during the year 1848, at the U. S. N. Observatory, Washington. Vol. IV. Published by authority of the Secretary of the Navy. 308 pp., 4to. Washington, 1856.—This volume of tables contains the results of observations with the transit instruments, mural and meridian circles and equatorial instrument; and also the mean right ascension of stars observed with these instruments, mean declination, mean

right ascension of sun, moon and planets observed with the west transit instrument; declination and semidiameters of the same as observed with the circles, and catalogue of stars observed in 1848.

13. *Annals of the Astronomical Observatory of Harvard College.* Vol. II, Part I. 136 pp., 4to, with numerous plates. Cambridge, 1857.—This part of the Cambridge Observatory Annals relates wholly to Saturn, and contains the observations made at the observatory by Wm. C. Bond, Director of the Observatory. The general results have been before the public for some time, and their high merit is well known. The observations are brought down to May of the present year. The series of plates contain 120 figures representing the appearances of Saturn and the ring at as many different times of observation.

14. *Patent Office Report*, 1856, CHARLES MASON, Commissioner of Patents. Volumes I, II, III, 8vo. Mechanics and one volume on agriculture.—The third volume, of 600 pages, is made up wholly of plates of the various machines, etc. patented at the Patent Office, descriptions of which are given in the first and second volumes. The agricultural volume contains many practical papers on agriculture, agricultural products and related topics, and is illustrated by several plates.

15. *Illustrated Annual Register of Rural Affairs for* 1858, with 130 engravings, Number four, by Luther Tucker & Son, Albany, 1858. Contains, besides other rural matters, neat plans of houses and grounds, trellices, etc.

16. *Illustrated Scientific and Descriptive Catalogue of Achromatic Microscopes manufactured by J. & W. Grunow & Co., New Haven, Conn.* New Haven. 8vo, pp. 104.—This work deserves honorable mention as a treatise of no small merit upon the general principles of optics involved in the construction of the microscope. This subject is considered under the following heads. Chapter I. Theory of the Microscope. Chapter II. Mechanical structure of the Microscope. Chapter III. Accessory apparatus. Chapter IV. Polarized light and its application to the Microscope. Chapter V. Practical directions. Eight distinct forms of the microscope, all original with these artists, are described and figured with their accessory apparatus. These are, No. 1, Educational microscope. No. 2, Students microscope. No. 3, Student's microscope. No. 4, Student's larger microscope. No. 5, Another form of student's microscope. No. 6, Portable microscope. No. 7, Large microscope. No. 8, Simple form of inverted microscope; to which may be added the more complete inverted microscope. The figures in this treatise are all original drawings by Sanford from the instruments, and are remarkably good examples of the xylographic art. These artists have attained a most enviable perfection in all the nicer details of construction in the mechanical portion of the instrument, while in the optical department they have also obtained the most satisfactory results. There are points of great interest to the microscopist discussed in their Catalogue which we may hereafter transfer to our pages. Such is § 124, on the "*Qualities of Object-glasses.*" Several novelties of construction are also for the first time here described and figured. The book is beautifully printed, and will be sent by post to any address upon the transmission of thirty cents in stamps to the artists.

17. *Annals of the Lyceum of Natural History of New York*, Vol. VI, Nos. 6 and 7, pp. 165–230. New York city: Wiley & Halsted. *Contents*—

G. N. Lawrence: Descriptions of new species of Birds of the Genera *Chordeiles* Swainson, and *Polioptila* Sclater. *Species*, Chordeiles Gundlachi from Cuba, C. Texensis of Texas, Polioptila melanura of Texas and California.

John H. Redfield: Descriptions of new species of North American Helicidæ.—Species, *Helix Elliotti* of the mountains of Georgia and North Carolina, and *H. barbigera* of Georgia.

J. T. Gulick: Descriptions of new species of Achatinella from the the Hawaiian Islands. Contains descriptions of 49 species, with figures on two plates.

18. *Supposed Meteorite.*—We have received from Mr. Thomas Bassnett of Ottawa, Illinois, specimens of scoria, with a description of their supposed fall on the 17th of June last, about ten miles south-southwest from that place. The account of the fall, as written out by L. H. Bradley on whose farm the scoria was found, states, that the time it occurred was fifteen or twenty minutes before 2 P. M.; the wind blew west by south. He says, "The cinders fell in a northeasterly direction in the shape of the letter V. The weather had been showery, but I heard no thunder and saw no lightning. There appeared to be a small, dense black cloud hanging over the garden in a westerly direction, or a little to the south of west. The cinders fell upon a slight angle within about three rods of where I was at work; there was no wind at the moment, or none perceptible. My attention was called first to the freak the wind had in the grass, and the next moment to a hissing noise caused by the cinders passing through the air. The larger ones were considerably imbedded in the earth, so much as only to show a small part of it, while the smaller ones were about one-half buried. I noticed at the time that the ground where I afterwards picked up the cinders showed signs of warmth, as there was quite a steam or fog at that particular point. I thought it singular, as the ground had been very cold previously."

The scoria is in rounded inflated pieces, like what have been called volcanic bombs, the exterior being glassy, and the interior very cellular. They are little over an inch in the longest diameter. Color black.

The paper, called the "Sunny South," of Aberdeen, Miss., of Sept. 17, 1857, describes a mass of lava as large as a barrel, "which fell near the farm of Mr. John Fortson, ten miles west of Aberdeen, on the 8th of July, 1856, and which excited a good deal of wonder and speculation at the time for hundreds of miles around."

The Illinois scoria is unlike any meteorite, and suggests the idea of a terrestrial origin. We know nothing about the Mississippi "lava."

Proceedings Boston Soc. Nat. Hist.—Vol. VI. p. 145, List and descriptions of eggs obtained in California; *E. Samuels.*—p. 145, On erosions of shells; *J. Lewis.*—p. 152, On a supposed new Siredon; *S. Kneeland.*—p. 155, On a new Succinea and Helix; *W. G. Binney.*—p. 157, On a new Guano; *A. A. Hayes.*—p. 158, Note on the wild turkey breeding with the tame; *Bryant.*—p. 160, A psychological view of the motions of Animals; *D. Weinland.*—p. 167, Cementation of Conglomerates; *A. A. Hayes.*—p. 173, 179, 194, Notice of J. W. Bailey; *A. A. Gould.*—p. 175,

Habits of Fishes; *N. E. Atwood.*—p. 178, Pearl-growing in China.—p. 181, On the Chinese Sugar Cane; *C. J. Sprague.*—p. 184, Nomenclature of the superposition of strata; *W. B. Rogers.*—p. 184, Notice of the death of Michael Tuomey.—p. 186, Notice of the death of Wm. C. Redfield—p. 192, List of Officers (J. Wyman, M. D., *President*, C. T. Jackson and D. H. Storer, *Vice Presidents*, S. L. Abbott, *Corresponding Secretary.*)—p. 192, List of Reptiles collected by E. Samuels in California; *J. N. Borland.*—p. 200, On the Sugar of the Chinese Sugar Cane; *A. A. Hayes.*—On the Burrowing Owl of South America, (*Athene cunicularia*); *N. H. Bishop.*—p. 206, On the movements of the earth worm; *S. Durkee.*—p. 207, On the Zonda of South America; *N. H. Bishop.*—p. 211, On a rock of organic origin looking like Trachyte; *A. A. Hayes.*—p. 217, On the slate rocks of Governor's Island, Boston Harbor; *W. B. Rogers.*—p. 227, Gum from California; *A. A. Hayes.*—p. 231, On the Birds of Keweenaw Point, L. Superior; *S. Kneeland, Jr.*

Proceedings of the Academy of Natural Sciences of Philadelphia. 1857.—p. 2, Catalogue of the species of Bembidium found in the U. States and contiguous regions; *J. L. LeConte.*—p. 10, Descriptions of several new Mammals from Western Africa (species of Semnopithecus, Cercopitheus, Microcebus, Vespertilio, Sorex, Sciurus); *John LeConte.*—p. 15, Notes on Aluminium; *W. J. Taylor.*—p 17, On the visual organs of certain species of the genus Unio; *I. Lea.*—p. 18, Note on Entozoa in the Naiades; *J. Leidy.*—Descriptions of American Land Shells; *W. G. Binney.*—p. 19, New species of invertebrates of N. Pacific Expedition; *W. Stimpson.*—p. 31, Descriptions of thirteen new Unios from Georgia; *I. Lea.*—p. 33, Catalogue of Birds collected on the river Muni, W. Africa; *J. Cassin.*—On the Crania of the Ancient Britons, with remarks on the people themselves; *J. B. Davis.*—p. 48, Reptiles of the Gaboon country, Western Africa; *E. Hallowell.*—p. 75, Synopsis of the genus Clivina and allied genera inhabiting the U. States; *J. L. LeConte.*—p. 83, Description of six new species of Unios from Alabama and of species of U. S. Naiades; *I. Lea.*—p. 87, Contributions to the Neuropterology of the U. States; *P. R. Uhler.*—p. 89, List of extinct Vertebrata, which have been discovered in the region of the Missouri River, with remarks on their Geological age; *J. Leidy.*—p. 91, On Columbian Guano; *W. J. Taylor.*

*Magnetical and Meteorological Observations, made at Toronto in Canada;* printed by order of her Majesty's Government, under the superintendence of Major-General Edward Sabine of the Royal Artillery. Vol. III. 1846, 1847, 1848, with abstracts of observations to 1855 inclusive. 456 pages 4to. London, 1857. Longman, Brown, Green & Longmans.

*Mémoires de l'Académie Royale des Sciences des Lettres, et des Beaux Arts, de Be gique.* Tome xxx, 1857. Contains, in science, Experimental and Theoretical researches on the figures of equilibrium of a liquid mass without weight, by *J. Plateau.*—Problem "des Crepuscules," by *Mr. Laigre.*—Influence of the lunar changes on the atmospheric pressure, *ibid.*—Fundamental notions on several elementary points in Geology, dynamics and transcendental Analysis, by *M. Lamasle.*—Researches on the development of Infusoria, by *M. J. d'Udekem.*—Observations on Periodical Phenomena.

*Memoires Couronnés,* ibid.—Vols. xxvii, xxviii. Scientific Papers: Development of the Lumbricus terrestris; *M. J. d'Udekem.*—Researches on the specific heat of some metals at different temperatures; *E. Bede.*—Cause of the scintillation of the stars; *Montigny.*

*Bulletin of the Acad. Sci. Roy. of Belgium.* Vol. xxii, contains the following papers in Zoology and Botany: Ichneumonologica Miscellanea; by *Prof. C. Wesmael* of Brussels.—On Cecrops Latreillii; *van Beneden.*—New species of Scolex; *J. d'Udekem.*—New classification of the setigerous Abranchiate Annelida; *J. d'Udekem.*—New species of Michelaria; *Strail.*—On the species of Hirundo, of the subgenus Cecropis; *E. de Selys-Longchamp.*—Vol. xxiii. On the Indigenous varieties of the Fucus vesiculosus; *J. Kickx.*—Additions to the Recapitulation of the hybrids observed in the family of the Anatida (see vol. xii, No. 10, p. 335, 1845); *Selys-Longchamps.*

*Faune Française, ou Histoire Naturelle, Générale et Particulière des Animaux qui vivent en France;* par Charles-Lucien Bonaparte et Victor Meunier.—A prospectus of this great work has just been issued. It is proposed to extend it to 24 volumes, 8vo, with a large number of illustrations, and to publish one volume every three months, commencing with the first of January, 1858.

# INDEX TO VOLUME XXIV.


A.

Academy of Sciences at Paris, Prizes of, 255.
see *Proceedings*.
Acids, organo-thionic, 142.
monobasic, amids of, 142.
Acid, glyoxalic, 426.
formula of oxalic, 425.
Alcohol, on a new biacid, *Limpricht*, 262.
Aluminium, 261.
Amer. Assoc. Proceedings, 301.
eleventh meeting, list of papers, read at, 301.
Amids of monobasic acids, *Cahours*, 142.
Ammonia-cobalt bases, *Gibbs* and *Genth*, 86.
Amylene, preparation of, 412.
Analysis, use of the prism in qualitative, *Gladstone*, 263.
Anesthesis by oxyd of carbon, 412.
by carbonic acid, 412.
Arctic polar sea, observations on, 247.
turf, *Kane*, 242.
Artesian wells, aerating water of, 261.
well of Moudorf, 158.
Artificial corundum, *Gaudin*, 273.
Ash of Lycopodium, 143.
Association, see American and British.
Astronomical observatory at Harvard, annals of, noticed, 448.
observations, for 1848, *M. F. Maury*, 447.
prizes for 1856, Lalande, 259.
star charts, notice of, 415.
Astronomy by *H. Bouvier*, noticed, 159.
Austrian Exploring Expedition, 260.

B.

*Bache, A. D.*, Terrestrial Magnetism in United States, 1.
*Bailey, J. W.*, bequest by, to the Bost. Soc. Nat. Hist, 158.
*Barnard, J. G*, on the gyroscope, 49.
*Bentham, G*, on generic nomenclature, 284.
on genus Clitoria, 282.
*Berkeley, J.*, on Cryptogamic botany, noticed, 151.
Bermudas, notes on, *A Scott*, 274.
*Berthelot*, on combinations of hydracids and hydrocarburets, 423.
*Bertoloni*, Miscellanea Botanica, noticed, 287
Bibliographic notices by *Nicklès*, 262, 413.
*Blodget's* U. S. Climatology, noticed, 299.
Bonaparte, C. L., death of, 299.
Boron, 261.
Botany, new works noticed by *A. Gray*; of Berkeley, 151; H Hoffmann, 153; C. Lehmann, 153; R. Caspary, 154; A. Chatin, 155; Linn Soc. Proceedings, 281; by C Mueller, 286; Bertoloni, 287; Harvey, 288; Henfrey's Elementary Course of Botany, 434; Naudin's Researches, 440.
monstrosity of Saponaria officinalis, 281.
*Bentham* on genus Clitoria, 283.
Indigofera Caroliniana, 288.
New Carices, *C. Dewey*, 46.
nomenclature in, *G. Bentham* on, 284.
Botanist Michaux, memoir of, *Durand*, 161.
*Bouvier's* Astronomy, noticed, 159.
*Bradley, F. H.*, discovery of new fossils in the Potsdam Sandstone, 434.
Bread from fern root, 281.
Bridges of iron, history of, 258.
British Association, address of president of, 415.
*Brush, G. J.*, on dechenite, 116.
on parathorite, 116.
on antigorite, 128.

C.

*Cahours*, amids of monobasic acids, 142.
new derivatives of salicyl, 425.
Calculating machine, Swedish, specimen tables, noticed, 447.
Caricography, *C. Dewey*, 46.
Carbon, protosulphid of, 426.
*Casamajor, P.*, a new mode of measuring crystals, 251.
*Caspary, R*, Consp. Syst. Hydrillearum, noticed, 154.
Cauchy, A., death of, 299, 408.
*Chatin, A.*, on Vaslisneria spiralis, noticed, 155.
Chemistry, inverse substitutions in, 423.
theory of substitutions in, 410.
China, Yellow river, *Macgowan*, 278.
Chlorids at Vesuvius, 273.
Chromium, blowpipe assay of, *Hilgard*, 387.
crystallized, etc., 141.
*Clark, T. E.*, Inaugural dissertation of, noticed, 447.
Classification of mammals, origin of, natural system, 410.
Cleavage, slaty, 150.
Climatology of U. States, by *L. Blodget*, noticed, 299.
Coast Survey Report, 1855, 159.
Cobalt, equivalent of, 427.

Cold weather at Dartmouth College, 155.
Combustion, influence of solar light on, *John LeConte*, 317.
Comet, 2d, 3d and 4th of 1857, 289.
Continents, on the relations of the coastlines of, and the Arctic and Antarctic circles, 433.
*Cook, G. H.*, subsidence of N. Jersey coast, 341.
*Cooke, J. P.*, chemical problems and reactions, noticed, 160.
Coprolites, analysis of. 111.
Cretaceous of the U. States, *J. Hall*, 72.
fossils of Nebraska, 275.
fossils of the carboniferous limestone of Indiana and Illinois, 276.
Crinoids, Devonian, of Coblentz, reference to paper on 280.
Curves, in forms of flowers, &c., 444.
Currents, northern oceanic, 237.
Crystals, mode of measuring, *P. Casamajor*, 251.

D.

*Dana, J. D.*, Fourth Supplement to Mineralogy, 107.
review of Dr. Kane's Arctic Explorations, 235.
Thoughts on Species, 305.
Parthenogenesis, 399.
on age of Connecticut river sandstone, 427.
note on the drift period, 432.
note on new fossils in the Potsdam Sandstone, 434.
*Dawson, J. W.*, on Devonian trees, 280.
Densities of vapors, calculation of, *Kopp*, 422.
*Deville*, on methods of preparing the elements, 141.
on Silicium and Siliciurets, 423.
Devonian trees, *J. W. Dawson*, 280.
*Dewey, C.*, Caricography, 46.
notice of Emmons's Report on N. Carolina geology, 427.
Diamagnetic bodies, disposition of force in, *Tyndall*, 234.
Dufrenoy, A., death of, 160.
*Durand, E.*, Biography of Michaux, 161.
Dutch liquid, 424.

E.

Earth, density of, 158.
figure of, 417.
*Ehrenberg's* Microgeology, noticed, 434.
Electrical excitation, on a new source of, *E. Foote*, 386.
Electric illumination, 411.
telegraph across the British Channel, 259.
Electricity, atmospheric, *Jobard's* theory of, 411.
Elements, on some general methods of preparing, *Deville*, 141.
*Emmons, E.*, geological report of N. Carolina, by, noticed, 427.

F.

*Faraday*, observations on divided gold, 269.
Fern root, bread from, 281.
Filtration through sand, *Witt*, 157
Fishes of China, work on, referred to, 446.
Fluoriferous sulphuric acid and its purification, *J. Nicklès*, 397.
Fluorine, *J. Nicklès*, 395.
*Foote, E.*, a new source of electrical excitation, 386.
Forces, on the interaction of natural, *Helmholtz*, 189.
Fossil bivalves, proportion of different ages, 150.
mammals, new oolitic, 144.
Devonian fishes of Ohio, *Newberry*, 147.
Fossils of S. Carolina, *Tuomey* and *Holmes* on, 159, 447.
Cretaceous, of Nebraska, etc., *Hall*, 72, 275.
of Vancouver's Island, 276.
of N. Carolina, by *Emmons*, 427.
Carboniferous, of Indiana, &c., *Hall*, 276.

G.

Galvanic apparatus, Ruhmkorff's, modified by *Ritchie*, 45, 143.
Geology, Cretaceous in U. S., *J. Holl*, 72.
Cretaceous of Nebraska and Pacific coast, 275, 276, 277.
Carboniferous fossils, Indiana, &c., 276.
Devonian trees *Dawson*, 280.
crinoids of Coblentz, 280.
notes on Bermudan, *Scott*, 274.
metamorphism forming magnesian rocks, *T. S. Hunt*, 272.
iceberg drift theory in, 239.
proportion of bivalves of different ages in, 150.
slaty cleavage in, 150.
age in, of Connecticut river sandstone, 427.
Illustrations of Surface, by *E. Hitchcock*, noticed, *J. D. Dana*, 430.
of the Globe, Key to, by *R. Owen*, noticed, 159.
supplement to Lyell's, noticed, 143.
new fossil mammals of the Oolite of England, 144.
of New York, discovery of new fossils in the Potsdam sandstone in, 434.
of Tennessee, by *R. O. Currey*, noticed, 280.
Geological report of New Jersey, third annual, noticed, 433.
of N. Carolina, by *E. Emmons*, noticed, 427.
survey of S Carolina, 145.
*Genth.* on ammonia-cobalt bases, 86.
reply to C. U. Shepard, 133.
*Gibbs, W.*, on the ammonia-cobalt bases, 86.
chemical abstracts, 140, 262, 422.
note on law of vapor-densities, 422.
*Gilliss's* U. S Naval Astronomical Exped., vol. vi, noticed, 159.
Glaciers, observations on northern, 239.
Glass, action of acids on, 395.
colored by gold, 271.
Glycerine, artificial production of, 140.
cane sugar from, 413.
Glyoxal and glyoxalic acid, 426.
*Godron* on the flora of Lorraine, noticed, 413.
Gold, observations on divided, *Faraday*, 269.

*Gray, A.*, botanical notices, see *Botany*.
*Graham's* chemistry, noticed, 160.
*Grunow's* catalogue, noticed, 448.
Guano, *W. J. Taylor* on, 177.
*Guyot*, heights of N. Carolina mountains, 277.
Gyroscope, *J. G Barnard* on, 49.
*H. A. Newton* on, 253.

H.

*Hall, J.*, on the U. S. Cretaceous, 72.
Cretaceous fossils of Nebraska, 275.
on Carboniferous Fossils, noticed, 272.
*Harvey's* Phycologia Australica, noticed, 283.
*Hayden, F. V.*, Nebraska fossils, 149.
geology of Missouri river region, 276.
fossils of Nebraska, 277.
*Haw, H.*, on natro-borocalcite of Nova Scotia, 230
Heat and work, *Helmholtz*, 196, 198.
Heat of the sun, effects of, *Helmholtz*, 207.
from condensation of bodies of planetary system, *Helmholtz*, 215.
see *Temperature*.
*Heer, O.*, on N. Carolina fossils, 428.
Heights of mountains of N. Carolina, 277.
of Himalayas, 278.
*Helmholtz, H.*, on the interaction of natural forces, 189.
*Henfrey's* Elementary Botany, noticed, 434.
*Hilgard, E. W.*, blowpipe assay of chromium, 387.
Himalayas, heights of newly discovered peaks, 278.
*Hitchcock's* Illustrations of Surface Geology, noticed, 430.
*Hobson*, organo-thionic acid, 142.
*Hoffmann, H.*, Witterung, &c., noticed, 153.
*Hooker* and *Thomson's* Præcursores ad Fl. Indica, 283.
*Hunt, T. S.*, on cherokine, 275.
probable origin of some magnesian rocks, 272.
Hybridity, *J. D. Dana*, 309.
Hydrocarburets, combinations of with hydracids, *Berthelot*, 423.

I.

Icebergs, northern, *Kane*, 239.
Iceberg theory of drift, 239, 432.
Indigo from the Indigofera Caroliniana, 288.
Iodids of organic radicals, new, 425.
Iron, influence of sulphur on, 330.
Itabirite rock of S. Carolina, 145.
Itacolumite rock of S. Carolina, 145.

J.

*Jackson, C. T.*, on agalmatolite, 273.
*Janoyer*, on the influence of sulphur on iron, 330.
Japan expedition, notice of report of volume including natural history, 447.
*Jones, G.*, on the zodiacal light, 289, 374.
*Jones, T. R.*, on Fossil Entomostraca, noticed, 446.

K.

*Kane, E. K.*, Arctic Explorations of, reviewed, 235.
*Kopp*, on law of densities of vapors, 422.

L.

Lava, see *Volcanic*.
*Lea, I.*, recent papers on bivalves by, 155.
*LeConte, J.*, of S. Carolina, influence of solar light on combustion, 317
*Lehmann, C.*, Revisio Potentillarum, &c., noticed, 153.
*Lieber, O. M.*, Report on geological survey of S. Carolina, noticed, 145.
Light, Jamin and Haughton's discoveries, etc. *Lloyd*, 420.
Linnæan Society, proceedings, noticed, 281.
Lithia and magnesia, on the separation of, *J. W. Mallet*, 137.
*Lloyd*, address of, before Brit. Assoc., 415.
*Lubbock, J.*, on parthenogenesis, 401.
Lycopodium, silica and alumina in ash, 143.

M.

Magnetic (paramagnetic) and diamagnetic bodies, disposition of force in, *Tyndall*, 264.
Magnetism, terrestrial, of U. States, *A. D. Bache*, 1.
at Brussels and Paris, 446.
notes on, *Lloyd*, 418.
Magnesian rocks, probable origin of, *T. S. Hunt*, 272.
Magnesium, 261.
*Mallet, J. W.*, on the separation of magnesia and lithia, 137.
Manganese, preparation and properties, 140.
*Macgowan, D. J.*, on the drying up of the Yellow river, 278.
*Maury, M. F.*, astronomical observations for 1848, 447.
Wind and Current charts, 300.
*Meek, F. B.*, cretaceous fossils, 275, 276.
Metamorphism in formation of some magnesian rocks, *T. S. Hunt*, 272.
Meteor in Minnesota, 158.
Meteoric iron of Mexico, *E. Pugh*, 295.
stones and meteors, *Helmholtz*, 206.
stone of Oesel, 295.
near Bremervörde, 295.
of East Flanders, 296.
Meteorite, of Mississippi, *W. J. Taylor*, 293.
supposed scoriaceous, 449.
Meteorology, *Maury's* wind and current charts, noticed, 300.
of U. States, *L. Blodget*, 299.
cold weather at Dartmouth College, 155.
Microgeology of *Ehrenberg*, noticed, 434.
Microscopes, *Grunow's* catalogue of, noticed, 448.
Michaux, memoir of, *E. Durand*, 161.
Miller, H., Testimony of the Rocks, by, noticed, 160.
Minerals, cabinets for sale, 296.
MINERALS—
Æschynite, analysis, *Hermann*, 111.
Agalmatolite, 273.
Allanite, analysis, 111.
Allophane of Woolwich, 111, 131.
Analcime of Kaiserstuhl, 111.
Annivite, new species, 111.
Antigorite, see Serpentine, 128.
Antimony ochre (bleiniere) of Cornwall, 113.
Antrimolite is mesolite, 128.
Apatite of Amberg, 111. Coprolites, 111.

MINERALS—
Aragonite, examined by *Leydolt*, 112; near the Arkansas, *Taylor*, 275.
Astrakanite? of Mendoza, 112.
Beryl, Davidsonite identical with, 112.
Binnite, see Dufrenoysite, 117.
Biotite, see Mica, 122.
Bismuthaurite. *Shepard*, 112.
Bismuthine of Riddarhyttan, *Genth*, 113.
Bismutite of S. Carolina, *Genth*, 113.
Bleiniere of Cornwall, 113.
Brookite of the Grieser valley, 113.
Breithauptite at Chatham, Ct, 113.
Calcite, new forms, *Q. Sella*, 113.
Calyptolite, an altered zircon, 113.
Cantonite, of Canton Mine, Ga., *Pratt*, 113.
Caporcianite, see Laumontite, 121.
Chalcodite, *Mallet*, 113.
Chalybite. locality of Baltimore ore, and in Kentucky, 114.
Cherokine of Canton Mine, 38, 114; *T. S. Hunt*, 275.
Chlorite, optical characters, 114; Pennine, 114.
Chlorite-like mineral with Tyrol margarite, 114.
Chlorid of Iron, of Vesuvius, 114.
Chrysolite, *Damour*, 114.
Cinnabar of Idria, 114.
Clay, porcelain, of Georgia, *Mallet*, 115.
Coal, localities, 115
Columbite of Greenland, 115; on the Bavarian, *Hermann*, *Oesten*, 115; of Middletown, *Chandler* 115.
Copiapite, *Kenngott*, 115.
Copper, native, of L. Superior, mercury in, 115; in hexagonal prisms, 115.
Coracite is Pitchblende, 125.
Crocidolite, see Hornblende, 120.
Cryolite is dimetric, 115.
Danburite, analogy to Anorthite, 115.
Dannemorite, see Hornblende, 120.
Datholite is oblique. *Senarmont*, 115.
Davidsonite, is Beryl, 112.
Demidoffite, of the Urals, 116.
Dechenite, *G. J. Brush*, 116.
Diamond, black, *Descloizeaux*, 116.
Dolomite, *Q. Sella*, 117.
Dufrenite, *F. A. Genth*, 117.
Dufrenoysite of Binnen, 117.
Eisennickelkies of *Scheerer*, called nicopyrite, 117.
Enargite? in S. Carolina, 117.
Epidote, analyses of, *Rammelsberg*, 117; a mangan-epidote of St. Marcel, *Deville*, 118
Epistilbite, form and analysis, 118.
Eudialyte, analysis, 118.
Eukolite is Eudialyte, 118.
Eusynchite is Dechenite, 116.
Fargite, 128.
Faroelite, *Heddle*, 118.
Fergusonite, see Tyrite, 129.
Fibroferrite, see Copiapite, 115.
Fichtelite, 447.
Freislebenite of Spain, 119.
Gadolinite, homœomorphous with euclase, 119.
Galactite of Glen Farg, *Heddle*, 128.
Galena, containing Cadmium, 119.
Garnet, *Damour*, 119.

MINERALS—
Gibbsite, 119.
Glauconite of Westphalia; of Alabama, 119.
Glossecollite, *Shepard*, 124.
Graphite, artificial, 119.
Gypsum, 119.
Harrisite of Georgia, 39, 120.
Hartite, *Kenngott*, 120.
Hematite, pseudomorphous octahedrons of, 120.
Hessite of Russia; of California, 120.
Heulandite, beaumontite identical with, 120.
Hitchcockite of *Shepard*, 41, 125, 133.
Hornblende (Dannemorite), 120.
Horn Silver or Kerargyrite, 121.
Hypoxanthite or Sienna earth, 121.
Iodine, free, in the fumaroles of Vulcano, 121.
Kerargyrite, of Russia, 121.
Lanthanite, of U. States, 43, 121.
Laumontite of the Tyrol, *Gericke*, 121.
Lead, native, in Mexico, 121.
Leucophane, *Rammelsberg*, 121.
Lievrite, angles of, and analysis, 122.
Limonite, reference, 122.
Linnæite, of U. States, *Genth*, 122.
Magnetite, pseud. after Chalybite, 122.
Margarite, analysis by *Faltin*, 122.
Marcylite, referred to Atacamite, 122.
Melinophane, see Leucophane, 121.
Mesolite, see Scolecite, 127.
Mica, 123.
pseudomorph after Orthoclase, 124.
after Scapolite, 123. ["Mica pseud." and "Unalt'd Scapolite" should be transposed.]
Misy, see Copiapite, 115.
Moronolite, *Shepard*, 123.
Molybdenite, crystals, 123.
Natroborocalcite, in Nova Scotia, *H. Haw*, 230.
Nepaulite, *Piddington*, 123.
Nicopyrite or Eisennickelkies, 117.
Nitrammite, 124.
Opal, 124.
Palladium ochre, or Palladinite, 124.
Parasite, *Volger*, 124.
Parastilbite, *von Waltershausen*, 124.
Parathorite, *Shepard; Dana; Brush*, 124.
Pennine, see Chlorite, 114.
Perofskite of Zermatt, 124.
Piauzite, *Kenngott*, 125.
Pitchblende, Coracite identical with, 125.
Plumbic Ochre of New Mexico, 125.
Plumbo-resinite, Hitchcockite referred to, 125; of Canton Mine, 41, 125.
Pyrargyrite and Proustite, crystals, *Sella*, 126.
Pyrites, Traversella twins, *Sella*, 126.
Pyromorphite altered, 126.
Pyromelane, of *Shepard*, 126.
Pyrochlore of Miask, 126.
Quartz, planes of, from *Descloizeaux*, 126.
Rastolyte of *Shepard*, see Stilpnomelane, 128.
Salt borings in Kentucky, 127.
Samarskite, analysis, *Hermann*, 127.
Sassolin, crystals, 127.
Saussurite of Silesia, *Chandler*, 127.

MINERALS—
Savite, *Breithaupt*, 127.
Schorlomite, *Shepard*, 127.
Scleroclase, see Dufrenoysite, 117.
Scolecite, *Heddle*, 127.
Senarmontite, of Algeria, 128.
Sericite slate, rock resembling, 273.
Serpentine, and Antigorite, 128.
Stassfurtite, 128.
Stilpnomelane and Rastolyte 128.
Tachhydrite, *Rammelsberg*, 129.
Tantalite of Kimito, *Hermann*, 129; of Chanteloube, *Chandler*, 129.
Telluric Silver, see Hessite, 120.
Topaz, crystals of, *Kokscharov*, 129.
Tourmaline, 129.
Tyrite, *D. Forbes*, 129.
Uranite, *Descloizeaux*, 130.
Vanadinite, *Rammelsberg*; *Kenngott*; *Schabus*, 130.
Vivianite, of New Jersey, 130.
Warwickite, 130.
Wavellite, of Chester Co., Pa., 130.
Wolfram, of Zinnwald, 130.
Yttrotantalite, *Chandler*, 131.
Zeolite of Skye, *Mallet*, 121.
Zircon from Brazil; of N. Carolina, 131.
Mineralogy, 4th supplement to *Dana's*, 107.
list of new works, 108.
Mitchell, E, death of, 299.
Moon, on absence of atmosphere, 416.
Mountains of N. Carolina, *Guyot*, 277.
see *Height*.
*Mueller, C.*, Synopsis Plantarum, &c., noticed, 286.

N.

*Naudin's* Researches, &c., noticed, 440.
Nebraska, cretaceous, *J. Hall*, 76, 275.
Nebular theory, *Helmholtz*, 203.
Nervous action, rapidity of, 445.
*Newberry, J. S.*, fossil fishes of Ohio, 147.
New Jersey, 3d Annual Geol. Rep. of, noticed, 433.
*Newton, H. A*, on the gyroscope, 253.
*Nicklès, J.*, correspondence of, 255, 408.
on fluorine, 395.
on fluoriferous sulphuric acid, 397.
Nickel, equivalent of, 427.
Nova Scotia natro-borocalcite, *H. Haw*, 230.

O.

OBITUARY—A. Dufrenoy, 160.
F. A. Michaux, 161.
E. Mitchell, 299.
C. L. Bonaparte, 299.
Thenard, 408.
Colla, 408.
Cauchy, 408.
Oceanic currents, northern, 237.
*Olmsted, D.*, memoir of W. C. Redfield. 355.
Organic morphology, *J. Warren* on, noticed, 443.
Organo-thionic acids, new series of, 142.
*Otto*, manual on poisons, noticed, 160.
*Owen, R.*, Key to the Geology of the Globe, 158.
on the coast lines of continents, 433.

P.

Palæotrochis of Emmons, 151.
Parthenogenesis,, observations on, *Burnett, Siebold, Lubbock, Dana*, 399.
Patent Office Report, noticed, 448.
*Peirce*, on the direction of the coast-lines of continents, 433.
*Petitjean's* process for silvering glass, 268.
Phosphatic nodules, analysis of, 112.
Photography at Paris, 261.
Planets, note on recent discoveries of, 415. 43d, 44th, 289.
Planetary system, observations on, *Helmholtz*, 203.
Plants, turf, of the Aretic, 242.
see *Botany*.
Polarization of light, *Stokes*, etc., on, 420.
Prizes at the Acad. Sci., Paris, 255.
Proceedings Boston Soc. Nat. Hist., noticed, 450.
Philad. Acad Nat. Sci., noticed, 450.
Pumpkin, on the native country of, 441.

R.

Ray Society, notice of, 296.
*Redfield, W. C.*, cyclones of the N. Pacific, 21.
biographical memoir of, 355.
list of publications of, 370.
*Ritchie, E. S.*, modified form of Ruhmkorff's apparatus, 45, 143.
Rocks, igneous, nature of liquidity of, *G. P. Scrope*, 217.
Rock, slate, of Hungary, resembling talcose slate, 273.
Ruhmkorff's apparatus modified by *Ritchie*, 45, 143.

S.

Salicyl, new derivatives of, 425.
Sandstone, see *Geology*.
Saulnier, P, notice of, *Durand*, 169.
*Scott, A.*, notes on the Bermudas, 274.
*Scrope, G. P.*, on the formation of craters, and the liquidity of lavas, 217.
*Shepard, C. U.*, reply to Dr. Genth, 38.
on a Petersburg meteorite, 134.
*Shepard's* Mineralogy, notice of, 109.
*Siebold*, on parthenogenesis, 400.
Silicium and metallic siliciurets, 423.
a new oxyd of, *Wöhler*, 140.
Siliciuret of hydrogen, 413.
Silver, action of light on chlorid, 263.
Silvering glass, *Petitjean's* process for, 268.
Smithsonian Contributions to Knowledge, vol. ix, noticed, 445.
Smithsonian Report for 1856, noticed, 301.
*Smyth*, astronomical expedition of, to Teneriffe, 417.
Speculum for telescopes, new, 259.
Species, thoughts on, *J. D Dana*, 305.
Stars, sudden appearance of, note on, 415.
Star charts, notice of, 415.
*Stimpson, Wm.*, on the Crustacea and Echinodermata of the Pacific shores of North America, 288.
Storms, cyclonic of the N. Pacific, *W. C. Redfield*, 21.
Storm, the Schuyler, 290.

Subsidence of N. Jersey coast, *G. H. Cook*, 341.
Sugar, cane. from glycerine, etc., 413.
Sulphur, different states of, 260.
Sun, influence of light of, on combustion, *LeConte*, 317.
note on constitution of, 416.
influences of, on the earth, *Helmholtz*, 207.

T.

*Taylor, W. J.*, on rock guano, 177.
on Aragonite near the Arkansas, 275.
on a nickel meteorite, 293.
translation by, of Janoyer, on the influence of sulphur on iron, 330.
Temperature of the earth, variations in, dependent on astronomical causes, *Meech*, 446.
Tennessee, geology of, by *R. O. Currey*, noticed, 280.
Thermometers, in Kane's Arctic Expedition, discrepancies among, 249.
Thenard, death of, 299.
Thought, rapidity of, *Ule*, 445.
Tides, notes on, *Lloyd*, 417.
Tornado the Schuyler, 290.
*Tuomey* and *Holmes*, on the fossils of S. Carolina, noticed, 159, 447.
Typhoons of the N. Pacific, *W. C. Redfield*, 21.
*Tyndall*, disposition of force in paramagnetic and diamagnetic bodies, 264.

V.

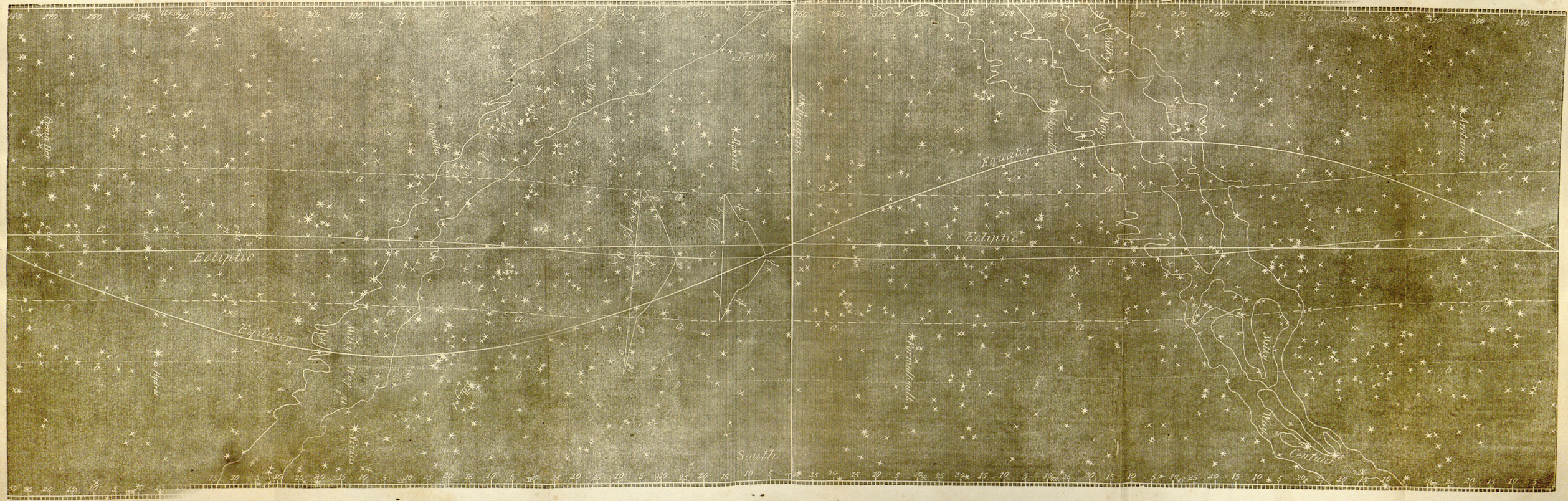
Voyage of discovery, Austrian, 260.
Volcanic craters and lavas, *G. P. Scrope*, 217.

W.

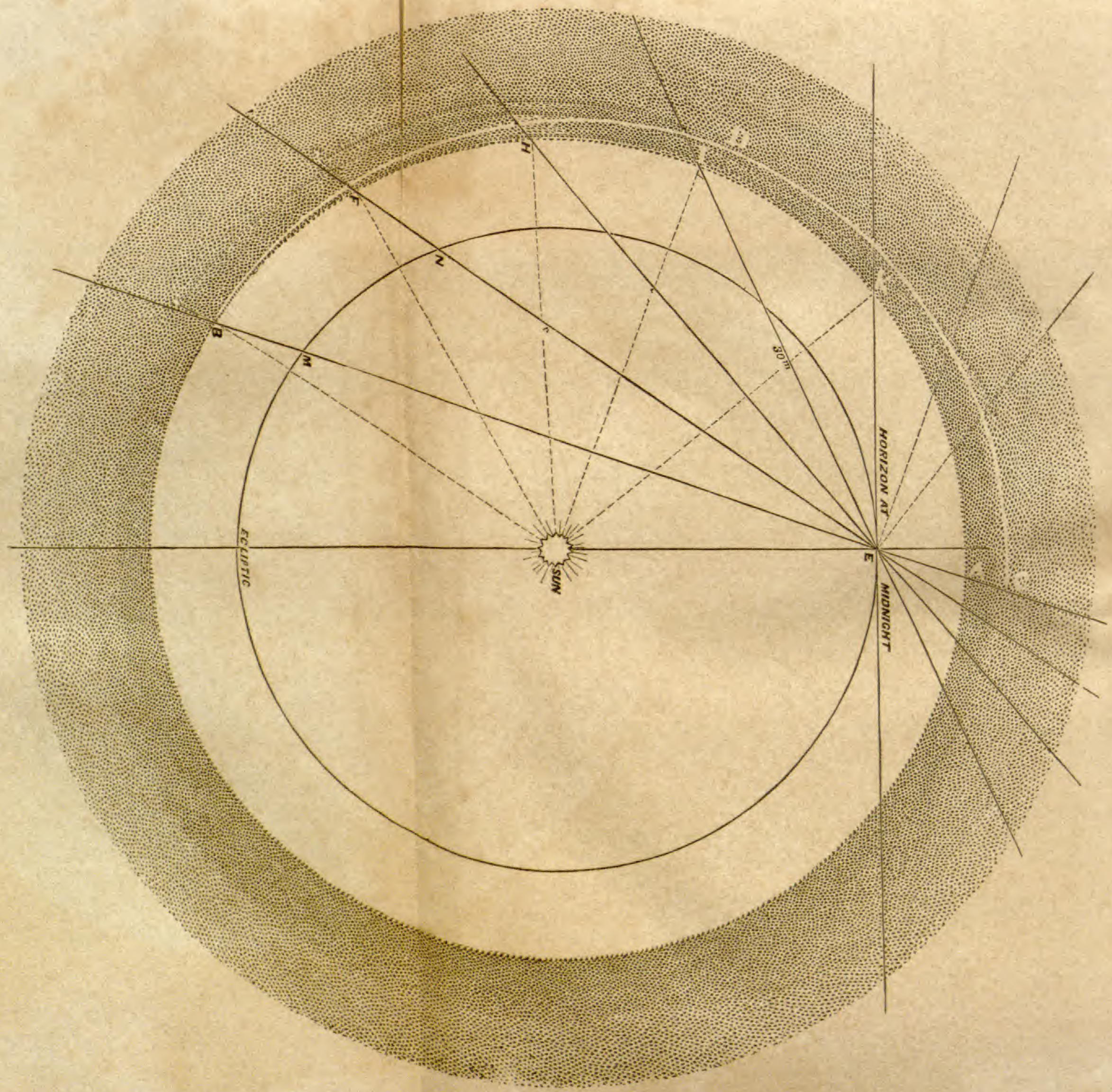
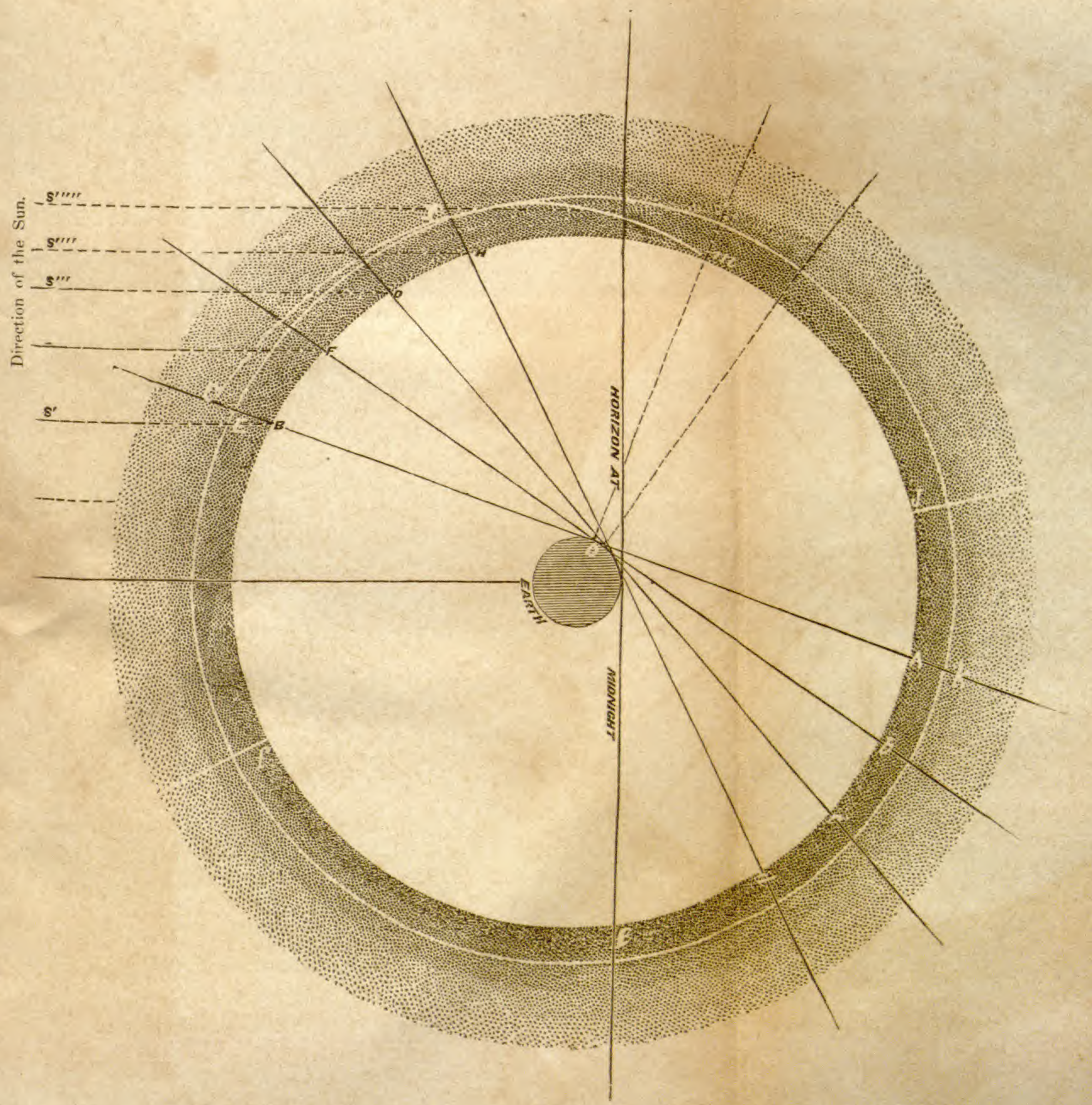
*Warren, G. K.*, Explorations in the Dacota Country, 300.
on organic morphology, noticed, 443.
Water, filtration of, through sand, *Witt*, 157.
*Wöhler*, on a new oxyd of silicon, 140.
Work, in machines, *Helmholtz*, 191.
*Wurtz*, on the production of glycerine, 140.
formula of oxalic acid, 425.
Dutch liquid, 424.

Z.

Zodiacal light, note on *G. Jones's* observations, 289.
*G. Jones*, 374.
Zoology, fishes of China, 446.
see also *Stimpson*, and *Fossil.*


North
South
Ecliptic
Equator
Milky Way
Spica Virginis
Regulus
Procyon
Sirius
Aldebaran
Pleiades
Capella
Castor
Pollux
Rigel
Betelgeux
Aphrat
Fomalhaut
Antares
Arcturus
Vega
Deneb
Altair

HELIOCENTRIC NEBULOUS RING.



## GEOCENTRIC NEBULOUS RING.